THE ORGANIZATIONAL AND STRUCTURAL DIMENSIONS OF HUNTER-GATHERER LITHIC TECHNOLOGY: THEORETICAL PERSPECTIVES FROM ETHNOGRAPHY AND ETHNOARCHAEOLOGY APPLIED TO THE MESOLITHIC OF MAINLAND BRITAIN WITH A CASE STUDY FROM NORTHERN ENGLAND.

by

Andrew M. Myers

Submitted in partial fulfilment of the degree of doctor of philosophy at the University of Sheffield.

1986

CONTENTS

List of Illustrations

List of Tables

Acknowledgments

A friend once commented that the production of a thesis may be likened to a prolonged labour before childbirth. Many individuals have, in their various ways, contributed to the conception, growth and delivery of this thesis. They remain, of course, blameless for the final product.

First, I wish to thank Dr. P.A. Mellars and Dr. R. Torrence for providing help and guidance in defining the scope of my research. Dr. R. Jacobi provided both useful discussions and access to important collections of material. Dr. N. Fieller provided access to an array of computer graphics routines and sage advice on cluster analysis, whilst R. Coleman and D. Savas assisted me with running Clustan at Manchester.

My thanks go to the numerous individuals who enabled me to have access to collections of material. In particular my thanks go to P. Beswick, J. Gilks, T. Manby, Dr. S. Pierpoint, T. Courtney, C. Hart, S. Palmer, Dr. M. Bishop, D. Garton and C. Wickham-Jones. I also wish to thank C. Bonsall, Dr. Foyatt and R. Gourlay for useful information, and D. Henson for putting me right on details of geology. Special thanks go to C. Mathers for his patience in listening to my ideas and anxieties, and to A. Hart for typing and correcting the manuscript.

Finally, only one person has suffered more than myself as a result of this research. To Gudrun I cannot adequately express my gratitude for her patience and strength.

This thesis is dedicated to Peter, who enabled me to retain a sense of perspective and an optimistic outlook throughout.

Abstract

The organizational (procurement, manufacture, maintenance/discard) and structural (composition, diversity, complexity) dimensions of contemporary hunter-gatherer technological strategies are discussed in terms of the selective advantages for limiting subsistence costs and/or risks. It is argued that where subsistence is primarily cost (energy) limited technological strategies differ from those employed where risk (time) is limiting. Anticipatory organizational strategies - embedded procurement and reduction, and curation - achieve their most significant role in time-stressed contexts where there are selective benefits in separating subsistence and technological schedules. Structural strategies - function-specific tools, diverse tool-kits, complex tool design - offer selective benefits where the act of food procurement is time-stressed. If subsistence is time-stressed but cannot be effectively separated from technological schedules tools may be made both reliable (high component redundancy) and maintainable (readily repaired) - the latter being facilitated by limiting component design thereby enabling materials of varied quality to be employed. The implications of differing organizational and structural strategies for the formation of the archaeological record and for the lithic analyst are discussed. Evidence concerning the environment, chronology, economy, settlement and technology of the Mesolithic of mainland Britain is reviewed. For the Earlier Mesolithic an alternative to the Clark model of subsistence and mobility is developed, whilst multivariate analyses of stone tool inventories and evidence concerning the function, complexity and design of microlithic tools provides the basis for suggestions as to the character and significance of the Earlier-Later Mesolithic transition. Analyses of lithic debitage from sites in northern England provide evidence for embedded procurement and reduction strategies during the Earlier Mesolithic consistent with the expectations of a model where autumn was spent in upland valleys engaged in intercept hunting, winter was spent in lowland residences

and spring/summer spent in lowland generalized strategies. In contrast, the Later Mesolithic witnessed a shift to lithic strategies designed to cope with higher residential mobility, reduced environmental redundancy and more evenly (spatial and temporal) distributed game.

Introduction

The analysis of lithic assemblages has, by virtue of the preferential survival of inorganic versus organic materials in the archaeological record, traditionally assumed a central role in prehistoric research. In the past, the study of lithics has contributed towards two distinct goals in the study of prehistory. The first of these traditional goals involved the need for establishing a chronological or sequential framework within which the archaeological record could be organized. Stylistic analyses of stone tools have, both before and since the advent of absolute dating methods, played a most valuable role in enabling archaeologists to provide such chronological frameworks within which regional archaeological sequences could be placed.

The search for chronologically sensitive lithic indicators has led a number of authors to examine the potentials of various lithic debitage classes, with varying degrees of success (Azouryand Hodson 1973; Bordes 1950; Newcomer and Hodson 1973; Pitts 1978a and b; Pitts and Jacobi 1979; Sanger 1981).

Beyond purely chronological considerations, however, attention has also focussed upon the second traditional goal of lithic analysis, the identification and interpretation of variability in the form and content of lithic assemblages. For the greater part of this century variability in the style and content of lithic assemblages has been discussed within a framework where artefacts were regarded as material expressions of the social identity or ethnic affiliations of their manufacturers. Variations in the stylistic content of assemblages were understood as a measure for discussing the social distance or proximity of prehistoric groups. Such approaches fell within the broad conceptual framework popularized by Childe (1929) whereby 'cultures were the material expressions of particular "peoples".' (Binford and Sabloff 1982: 141).

The controversy surrounding the interpretation of Mousterian inter-assemblage variability (Binford 1973; Binford and Binford 1966; Bordes 1973; Bordes and Bordes 1970; Collins 1970; Mellars 1970) saw the conventional Childean explanatory framework challenged by the alternative proposition, that such variability might reflect organizational differences in the activities undertaken by particular tool assemblages. Resistance to the 'functional' argument reflected the level of commitment to the traditional paradigm on the part of many authors. We might understand the established nature of the cultural/stylistic paradigm if we remember that Thomson's now famous account of seasonal variations in Australian hunter-gatherer subsistence and technology was published as early as 1939.

The Mousterian debate served not only to stimulate fresh interest into the relationship between stylistic and functional attributes (Close 1978; Dunnell 1978; Jelinek 1976; Sackett 1973) but also drew the attention of archaeologists to the potential complexity of factors responsible for variations in the form and content of the archaeological record. As research interest into the behavioural diversity and implications for archaeology of prehistoric groups developed then, so too, archaeologists began to ask increasingly diverse questions about the past. In particular, as research interest into the behaviour of hunter-gatherers grew a situation emerged where attention had, as noted by Gamble (1979),

> 'shifted from technology, as the principal interest, to considerations of resource exploitation, demography, settlement location, interaction and mating networks.'
>
> (35).

Somewhat ironically, therefore, the increased demands being placed upon the archaeological record, given that there has not been any fundamental change in the composition of the archaeological record, has meant that if archaeologists wish to address these questions then, inevitably, attention must return to the very thing from which it had shifted - namely the lithic technology of hunter-gatherers.

The need to develop fresh analytical approaches in the study of archaeologically recoverable data has stimulated research into the study of several categories of artefactual remains. Most notably, the study of faunal remains has, in recent years, witnessed considerable advances in theory and methodology. However, given the dominance of lithics in the archaeological record of hunter-gatherers it is somewhat surprising to realize the relative slowness in the development of theory and methodology connected with their analysis. Certainly, recent years have seen the growth of research into such lithic related areas as micro-wear (Hayden 1979; Keeley 1979; Semenov 1964), lithic fracture mechanics (Ackerley 1978; Bonnichsen 1968; Crabtree 1972; Speth 1972, 1974, 1975), manufacturing techniques (Bordes and Crabtree 1969; Crabtree 1968; Newcomer 1971, 1975), idiosyncratic variability (Gunn 1975; Spier 1975), breakage patterns (Russell 1967; Witthoft 1969), thermal alteration (Mandeville 1973; Weymouth and Mandeville 1975) and stage analysis (Bradley 1975; Collins 1975; Muto 1971; Sheets 1975), to name but a few. In as far as this evidence for considerable research effort has created a series of specialist fields of enquiry then lithic technology has developed rapidly. However, in view of the plea that lithic research should 'not be totally independent or self-serving' (Crabtree 1975: 6) there has been a tendency for lithic technology research to create 'self-contained fields of scholarship' (Dunnell 1982: 2).

The general failure of lithic technology research to achieve a productive integration into the broader realm of prehistoric analysis, with a few notable exceptions (i.e. Cahen et al. 1979), may be attributed to many factors. Arguably, however, it has been primarily the absence of general theory construction which has fostered the development of self-serving lithic technology research. Without a general theoretical framework within which the aims and results of such research could be directed and applied it has been difficult to establish the sorts of questions concerning prehistoric behaviour which such research might address. As noted by Torrence (1983: 11), in hunter-gatherer research the absence of developed general theory concerning technology has resulted in the comparative absence of fresh analytical approaches to prehistoric data-sets.

For all the reasons set out above the recent initiation of general theory integrating hunter-gatherer subsistence, settlement and technology (Binford 1973, 1976, 1979; Torrence 1983) represents, therefore, a major development in the potential for lithic analysts to address important behavioural issues through the archaeological record of hunter-gatherers.

Accordingly, this thesis represents an attempt to develop the integration of theory concerning hunter-gatherer subsistence and settlement with theoretical perspectives on the adaptive role of lithic organization and structure (chapter 2) and to apply these perspectives to the archaeological record of the Mesolithic of mainland Britain (chapters 3, 4 and 5). Over the years, since the formative works of J.G.D. Clark (1932, 1936), Mesolithic research in Britain has flourished through studies of chronology (Jacobi 1973, 1976; Mellars 1974, 1976c; Switsur and Jacobi 1975), economy (Clark 1952, 1954, 1972; Clarke 1976; Jacobi 1978b; Mellars 1975, 1976b, 1978), industrial and settlement variability (Mellars 1976a), lithic style zonation (Jacobi 1978a, 1978c, 1979a, 1981) and regional patterns of lithic production (Care 1979, 1982; Mellars and Reinhardt 1978).

Whilst there has been a considerable improvement in the number of findspots and excavations (Wymer 1977), associated with increasing numbers of contextually secure absolute dates, the Mesolithic archaeological data-base remains, with certain notable exceptions (Clark 1954, 1972; Coles 1971; Mellars 1978b; Wymer 1962), dominated by lithic industries. Consequently, the Mesolithic of mainland Britain represents a suitable context within which to apply fresh theoretical perspectives on hunter-gatherer lithic technology.

The development of an integrated theory of the adaptive role of lithic organization and structure within this thesis draws heavily upon recent contributions from ethnographic and ethnoarchaeological research into contemporary hunter-gatherers. Whilst ethnography has a long established role in archaeological interpretation the approach adopted here differs in certain fundamental respects from the traditional framework for integrating contemporary studies in archaeological research. Such is the importance of distinguishing between the traditional and the present approach that chapter 1 deals specifically with the relationship between ethnography, archaeology and understanding the past.

The overall aim of this thesis is to examine and illustrate the potentials for lithic analysis undertaken within an integrated theoretical framework. As is surely the case with all such research it is hoped that what follows may prove of interest and relevance to all engaged in the archaeological investigation of prehistoric hunter-gatherers.

Chapter One:

Ethnography, archaeology and understanding the past

Introduction

> 'I fear, both its authors and its original destination will ever remain unknown. Conjecture may wonder over its wild and spacious domains but will never bring with it either truth or conviction.'
>
> (Colt Hoare 1807 on Newgrange - in Daniel 1962).

The archaeological record has always posed fundamental problems to those wishing to understand prehistoric behaviour. Ever since the formative years of the discipline prehistorians have expressed their anxiety over the problems of converting observations on the static, mute archaeological record into meaningful statements about the dynamic processes which gave rise to its formation. Just as this was a source of agonizing for the antiquarians then so too it has remained a central issue in the archaeological interpretation of the past.

Over the past two decades concern over the interpretative methodologies and procedures of archaeologists has produced intense and, sometimes, acrimonious debate. The 'new archaeology' of the mid-sixties and early seventies was marked by numerous published positional statements seeking to identify and replace traditional approaches with more productive, explicitly developed explanatory frameworks (Binford 1962, 1964; Clarke 1968; Fritz and Plog 1970; Morgan 1973; Plog 1974, 1975; Redman 1973; Sabloff and Willey 1967; Tuggle et al. 1972; Watson et al. 1971). It is historically unfortunate that this proliferation of publications has been subsumed under the collective banner of 'the new archaeology' as the diversity of positions represented can, in retrospect, be seen to far outweigh the unity of purpose shared (Binford 1977, 1981).

Despite the resulting confusion over the specific approaches advocated by the new archaeology movement the consequences for the aims and procedures of prehistoric research have been considerable. Concern for the explicit development of theory and the interpretative methodologies of archaeologists has changed many aspects of archaeological reasoning. Awareness of the complexity of archaeological formation processes has stimulated new approaches to the task of understanding and interpreting archaeological patterning.

Central to many of the developments has been the acceptance that the processes responsible for the formation of the prehistoric record are in the past and beyond direct observation. From this it is clear that our understanding of the processes responsible for archaeological patterning is largely dependent upon learning from contemporary experience of current processes. As has been stated,

> 'Our knowledge and perception of the world are necessarily the products of observation and experience regardless of whether this is explicitly recognized....'
>
> (Smiley et al. 1980: V).

The emphasis given to the explicit examination of contemporary processes as the basis for developing our understanding has been at the heart of the radical change in the relationship between ethnographic and archaeological research. The impact of this change upon hunter-gatherer research in particular has had far reaching consequences in the study of prehistory and in the ways in which studies of contemporary societies have contributed or begun to contribute towards our understanding of the past. The rest of this chapter will attempt to contrast the traditional relationship between ethnographic and archaeological research with the emerging relationship and identify the significance of this change to archaeological reasoning and methodology.

1) <u>Traditional approaches to the past through studies of the present</u>

Archaeologists have always been largely dependent upon their knowledge and experience of the present in interpreting the past. The documentation of societies whose technology, settlement structures or economy resemble, at least superficially, those of the prehistoric record has provided a rich and convenient source of inferred parallels for prehistorians. Accordingly, analogy with ethnographic societies has formed the traditional currency in the relationship between ethnography and archaeological interpretation (Orme 1973). As a means of placing some 'behavioural flesh' upon 'artefactual bones' analogy has, despite the misgivings of certain archaeologists, (Hawkes 1954; Smith 1955), persisted as the primary role of ethnography in discussing the past.

Over the years, however, the use of inductive arguments by analogy has, itself, undergone various procedural developments.

a) Direct historical approach

The direct historical approach (Steward 1942), variously labelled as the 'continuous' (Gould 1978a: 255) or 'specific' (Ascher 1961: 319) approach, grew in recognition of contexts where ethnographic or ethno-historical accounts provided a historical continuity of prehistoric (pre-contact) behaviour. It was argued that such observational accounts could be projected in their details of native behaviour back into pre-contact contexts. The archaeological record could, in this way, be discussed in behavioural terms - the functions of tools and structures inferred from their ethnographically observed contexts. The philosophy for such approaches was clearly stated thus:

> 'Methodologically, the direct historical approach involves the elementary logic of working from the known to the unknown.'
>
> (Steward 1942: 337).

Despite the undoubted common sense of utilizing observations on early contact behaviour in reconstructions of the immediate pre-contact situation the limitations of such approaches underline the general weakness with simple analogues. Quite apart from the geographical limitations in the applicability of such approaches the selective and frequently inaccurate nature of early ethno-historical accounts counsels for caution in their acceptance and usage (McBryde 1982). More importantly, such approaches do nothing, in themselves, to develop an understanding which would enable us to anticipate behaviour differing from that recorded. Since there is no guarantee of consistency in pre-contact behaviour either spatially or temporally such approaches may only prove useful 'in a restricted geographical and temporal frame.' (Binford 1977: 8). In fact, as is true of analogues in general, such approaches do not, of themselves, contribute to our understanding, in a predictive sense, of the diversity of human behaviour.

b) The new analogy

As a response to situations where direct historical analogies were not applicable and in recognition of the need to avoid what Yellen (1977) has termed 'grab-bag analogy' (7) (i.e. the uncritical usage of ethnographic parallels) a number of authors attempted to establish criteria for the selection of appropriate analogues. Clark (1953) proposed that archaeologists should,

> 'attach greater significance to analogies drawn from societies existing under ecological conditions which approximate those reconstructed for the prehistoric culture under investigation.' (355).

Such approaches, variously labelled 'the new analogy' (Ascher 1961: 319) or 'discontinuous' (Gould 1978a: 255) approach, answered some of the previously voiced misgivings concerning analogue selection (Childe 1956). The assumed relationship between aspects of environmental structure and the adaptations of human groups was founded upon the concepts developed by Steward (1936, 1938) and has developed into the so-called 'new ecology' (Bettinger 1980: 191). As will be discussed later there can be little doubt that ecologically based approaches to the study of hunter-gatherers have radically altered our understanding of such societies. However, the criteria, as developed by

Ascher (1961), for the use of the new analogy contains an inescapable tautology. In proposing that archaeologists should 'seek analogies in cultures which manipulate similar environments in similar ways.' (319) we are invited, in essence, to confirm the consequent. Such approaches merely lead archaeologists to confirm their own preconceptions of prehistoric behaviour by selecting analogies which conform to their existing ideas on the behaviour of prehistoric groups. In other words, it is assumed that we already understand the prehistoric adaptations under consideration.

Once again, we see analogy serving as a means of extending prehistoric reconstruction but not actually contributing to our understanding of behaviour. The fundamental limitation of analogue use has been neatly defined by Freud:

> 'Analogies, it is true, decide nothing, but they can make one feel more at home.'
> (1933).

As long as the relationship between ethnography and archaeology was based upon analogue use, even under its various guises, our capacity to understand the diversity of human adaptation was confined within the limits of documented behavioural accounts and subject to archaeological 'common sense' reasoning (Binford 1983: 7). Given the limitations of analogy it is not surprising that, for many archaeologists, ethnography remained an exotic and quite distinct discipline of occasional value in illustrating possible prehistoric behaviour.

2) Beyond analogy?

By the time of the Man the Hunter symposium of 1966 the growing dissatisfaction with the relationship between ethnography and archaeology had reached crisis point. Ecologically inspired research into contemporary hunter-gatherer societies had grown and flourished. Individual case studies had served to undermine traditional assumptions concerning hunter-gatherer behaviour and had produced a major departure in research methods and aims from the traditional concerns of ethnography. In place of detailed descriptive accounts of ritual, ceremony, kinship and taboo etc. ethnographers increasingly focussed their attention upon the ecological context of subsistence and settlement behaviour. As numerous case studies revealed, contrary to traditional assumptions, that many hunter-gatherers exhibited a primary dependence upon plant-foods and that subsistence effort accounted for a small proportion of daily activity (Lee 1968, 1969; Lee and De Vore 1968b) a normative model of hunter-gatherer behaviour based around these new perspectives emerged.

a) Normative models

A number of authors (Steward 1955; Sahlins and Service 1960; Service 1962; Fried 1967) have attempted to classify ethnographically documented societies according to their political, social and economic characteristics. These taxonomic approaches necessarily constructed types which reflected the preponderance of societies with particular combinations of political, social and economic characteristics in the ethnographic record. In the search for commonality between societies the internal similarity of cases within types was emphasized at the expense of diversity in ethnographic societies (see Service 1962: 46 - 54).

The Man the Hunter symposium (Lee and De Vore 1968a) saw many authors employing a normative model of hunter-gatherer society which drew heavily upon those studies where a dependency upon plant foods, high mobility and egalitarian social organization had been documented. Once again, this normative model found argumentative support in the statistical preponderance of societies in the current ethnographic sample exhibiting these features. As stated by Lee (1968),

> 'the basis of Bushman diet is derived from sources other than meat...and appears to be a common feature among hunter-gatherers in general. Since a 30 to 40 percent input of meat is such a consistent target for modern hunters...is it not reasonable to postulate a similar percentage for prehistoric hunters?'
>
> (43).

Somewhat surprisingly this general proposition was made despite a clear awareness of the diversity of dietary strategies amongst hunter-gatherers and of the rather geographically biased composition of the current ethnographic sample which, of itself, must warn against assuming that the current sample may be regarded as quantitatively representative of prehistoric adaptations.

Nonetheless, the willingness to reason from such statistical generalizations gave rise to a normative view under which hunter-gatherers were characterized as plant-food dependent, highly mobile, technologically simple, living at low levels of population density and vehemently egalitarian. To what extent the popularity of such a model owed as much to the disillusionment of western society with the contemporary social and political atmosphere of the late sixties as with any positive ethnographic methodological philosophy is open to debate. What is clear is that for archaeologists the normative model found widespread acceptance (Harris 1979: 80; Hassan 1979: 140; Mellars 1976a: 375 - 376).

In retrospect, the willingness to embrace the new general theoretical perspective of the ethnographically based normative model can be seen to relate to the relationship between ethnographic research goals and archaeological interpretative methodology. Despite the shift towards ecologically based ethnographic research a fundamental gap existed between archaeological data requirements and the data available from ethnographies. Ethnographers, whilst analyzing and describing the subsistence and settlement systems of hunter-gatherers within an environmentally conscious framework paid little or no attention to the consequences of such behaviour for the formation processes of the archaeological record of contemporary groups. Put another way, whilst ethnography provided the basis for radical changes in perspectives on hunter-gatherer behaviour the required information on the dynamics of archaeological site formation processes was not presented. Consequently, archaeologists willingly adopted the new general perspectives on behaviour whilst remaining uninformed about the archaeological implications of such behaviour.

In this way a somewhat paradoxical situation developed with archaeologists struggling to apply the new wisdom within methodologies largely unaltered from the days when concern for providing a relative chronological framework for the archaeological record had seen the development of approaches emphasizing the stylistic/cultural paradigm for interpreting patterning in artefactual evidence.

b) The birth of ethnoarchaeology

Awareness of the need for archaeologically referable data from ethnographic studies was evident at the Man the Hunter symposium. Both ethnographers and archaeologists recognized that ethnography did not, at that time, furnish archaeologists with the necessary information. Some suggested that ethnographers should develop an awareness of archaeological data requirements (Sharp 1968: 288) whilst others proposed a more active role for archaeologists in studying contemporary societies (Clark 1968: 289).

In fact, calls for the adoption of common aims in ethnography and archaeology (Binford 1962; Taylor 1948; Willey and Phillips 1958) had long since established a growing commitment, particularly amongst American researchers, to the archaeological study of contemporary groups. As stated by Binford,

> 'if archaeologists and ethnologists are to work with common problems, their observations must be geared toward gathering data on the same variables, ...'
>
> (1968: 271).

Early attempts at studying the 'archaeological patterning of behaviour' (Gould 1977: 162) included the 'action-archaeology' of Kleindienst and Watson (1956) and the work of Longacre and Ayres (1968). Since then, however, the growth of ethnoarchaeology (a term coined by J.F. Fewkes at the turn of the century), variously labelled as 'living archaeology' (Gould 1980) and 'archaeological ethnography' (Stiles 1977: 88), has produced a wide range of studies in differing geographical/environmental contexts (Binford 1978a; Gould 1968, 1971, 1977, 1978a, 1978b, 1980; Yellen 1977).

The development of ethnoarchaeology has eroded the methodological and philosophical boundary between ethnography and prehistory, establishing the basis for a new relationship and a new currency in the use of contemporary observation for interpreting archaeological patterning. At the same time, however, the erosion of the distinction between the two disciplines has demanded that the philosophy of research into the behavioural and material patterning of societies be re-examined.

The inadequacy of traditional analogue-based reasoning and the demise of normative thinking (Bettinger 1980: 192 - 3) has called into question not only the role of ethnographic/ethnoarchaeological research in interpreting and understanding the past but also the philosophy of applying knowledge of contemporary behaviour and processes to past contexts. At the very heart of these issues lies the question of uniformitarianism.

3 Uniformitarianist philosophy

For archaeologists the problems of understanding the past have always been those of,

> '(a) how we get from contemporary facts to statements about the past, and (b) how we convert the observationally static facts of the archaeological record to statements of dynamics.'
>
> (Binford 1977: 6).

If we seek to understand the past from our knowledge and experience of the contemporary world and how it operates then, by implication, we must invoke and be constrained by the principle of uniformitarianism. Many authors have expressed doubt and concern over the degree to which we may be justified in assuming that conditions and processes in the contemporary world are representative of conditions and processes in the past (Bailey 1983: 3; R.A. Gould 1980: 30 - 36, 1978a: 250).

At this point it is important to draw a distinction between methodological and substantive uniformitarianism. Methodological uniformitarianism is inherent to the reasoning of all empirical sciences (Gould 1965: 224). Under the precepts of methodological uniformitarianism it is held that there are universal principles by which the world operates and renders our task as being to 'establish natural laws by observing present processes and then extrapolate the laws.' (Gould 1965: 226). A belief that there are universal principles by which the world operates and that the recognition of such principles is central to the advancement of understanding is integral to proper scientific procedure. For many, however, the study of human adaptational or behavioural diversity is not considered to be within the realm of scientific procedural philosophy. For these people, therefore, there are no universal principles governing human behaviour and the past, as well as the present, must remain the subject of highly particularistic debate through inductive reasoning and interpretation. For those who believe in the existence of universal principles in the behaviour of man, however, methodological uniformitarianism must underpin their research, as with all other empirical sciences.

Substantive uniformitarianism, however, involves the extrapolation of 'observed rates or conditions to past times' (Gould 1965: 226) and is, therefore, problematic in that, whilst we may be better off seeking to understand the past in terms of contemporary, observed processes and rates of change, we must be aware that such conditions may have differed in the past (S.J. Gould 1980): 151). Once again, we are not unique in being confronted with such problems as they are common to all disciplines where phenomena beyond direct observation are the subject of discussion and interpretation. The point here, however, is whereas methodological uniformitarianism is philosophically central to the scientific investigation of the world substantive uniformitarianism relies upon establishing the degree to which our inferences concerning past processes and conditions may be justifiably based upon a knowledge of contemporary dynamics.

From this it can be seen that such justification stems, largely, through our capacity to establish the shared conditions of past and present systems. In this our assessment of the shared conditions of past and present systems is 'conditional and may be false' (Binford 1981: 27). In fact, it is from this conditional status of our reasoning that we find the point at which prehistoric research may attain its most productive role in developing our understanding of the world. If all we could achieve, as prehistorians, were the transposition of contemporary knowledge into prehistoric contexts then, in the final analysis, the study of prehistory could never contribute to the development of theory or our understanding of how the world operates. The study of prehistory would, therefore, represent little more than an intriguing diversion to the more productive pursuit of ethnographic research.

As evidence of the positive contribution which prehistory can make to our understanding we may consider the recent development of perspectives on the adaptational behaviour of pre-Homo sapiens sapiens populations. In this case we clearly are dealing with the behaviour of species not represented in the contemporary sphere of observation. Yet, by contrasting our knowledge and archaeological expectations of human hunter-gatherer systems with the archaeological record of proto-human behaviour it is becoming increasingly clear that certain so-called principles - such as food-sharing and residential site behaviour - may have differed amongst proto-human populations in comparison with the behaviour of human populations (Binford 1983: 40 - 59).

In many respects our capacity to reject substantive theory derived from contemporary observation may prove more difficult in the study of prehistoric human populations since it will demand considerably more of us in establishing those conditions not shared with contemporary populations. Nonetheless, the potential exists for prehistory to make a positive contribution towards general theory construction. For this to happen, however, it is essential that we, as archaeologists, attempt to learn from the diversity of contemporary behaviour. To this end simple analogies or normative models cannot serve the development of our understanding. In the derivation of general theoretical principles of behaviour we need to learn from the available diversity of observable behaviour (compare Lee 1968 with Foley 1982).

Furthermore, for archaeologists to be able to apply and test general theory to prehistoric data we need to develop an understanding of the relationships between behavioural diversity, adaptational principles, and patterning in the formation of the archaeological record. Concern for the development of such an understanding whereby we may convert the static facts of the archaeological record into meaningful statements about the dynamic properties of past cultural systems falls within, what

Binford (1977, 1981) has termed middle-range theory development. As with the development of general theoretical perspectives ethnoarchaeological research will only contribute to middle-range theory of general utility once practitioners avoid the sort of ethnocentrism which dogged normative models. Reasoning from individual case studies on the relationship between behaviour and site-formation processes to all situations runs the danger of failing to accommodate conditional diversity (see Binford 1978b and Yellen 1977). As with general theory development middle-range theory construction will ultimately prove productive through accounting for the diversity of archaeological site formation processes between contexts and between ethnographically observed cases.

As ethnography and ethnoarchaeology have developed over recent years the prospects for integrating general theory with middle-range theory has produced real potential for archaeologists to re-examine the archaeological record. This chapter has attempted to provide a brief historical perspective on the relationship between contemporary observation and prehistoric interpretative methodology. Whilst analogy will continue as a dimension in prehistoric reconstruction it is clearly time that more productive use were made of contemporary observation in prehistoric research. The following chapter will seek to develop an integrated perspective of hunter-gatherer subsistence, settlement and technology within general theoretical principles. The aim is to establish an approach for examining the archaeological record and throw fresh light upon the behaviour of prehistoric hunter-gatherers. To this end attention will be focussed upon the organizational and structural dimensions of hunter-gatherer lithic technology and their adaptational roles within subsistence and settlement organization. In developing an integrated theoretical perspective it is hoped that by seeking to account for the diversity of behaviour represented in the current ethnographic sample, rather than employing direct analogies with individual contexts, the prospects for a more fruitful relationship between ethnographic and archaeological research may be demonstrated.

Chapter Two:

Towards an integrated theory of hunter-gatherer subsistence, settlement and technology

Subsistence, mobility and scheduling: introduction

Over the past two decades hunter-gatherer research has focussed attention upon the relationship between hunter-gatherer economic strategies and environmental variables. In particular, the examination of the influence of variability in the spatial and temporal structuring of environmental resources upon hunter-gatherer subsistence and mobility patterns has provided important contributions in developing our understanding of the diversity of hunter-gatherer adaptations. At a global level it is now possible to relate adaptations to the distribution of specific environmental characteristics.

Harris (1969) has discussed the significance of differing ecosystem types for hunter-gatherer exploitation patterns. Attention is specifically focussed upon the characteristics of two diametrically opposed ecosystem types - generalized and specialized - and their implications for understanding behavioural diversity. Consideration of specialized and generalized ecosystem characteristics provides us with a useful starting point for discussing the implications of differing conditions of environmental structuring for hunter-gatherer exploitation strategies.

a) Generalized ecosystems

Globally, the availability of incoming solar radiation combined with the overall distribution of rainfall determines the potential net primary productivity of any given region. Generalized ecosystems occurring in low latitudes are subject to relatively stable regimes in the amount and annual distribution of solar radiation. Consequently, net primary productivity tends to be high. In tropical rainforests, for example, above-ground net primary productivity can be as high as 3600 - 7200 $gm/m^2/yr$. (Harris 1969: 4). The combination of high primary productivity and stability promotes the development of ecological niches for all trophic levels thereby providing the basis for high levels of species diversity and inter-species competition. The decline of any particular species is, therefore, of little significance to the ecosystem since the niche is rapidly occupied by competing species. As a result, the overall productivity of generalized ecosystems tends to remain stable exhibiting only minor fluctuations from year to year. This productive stability is further enhanced through the prevailing mechanisms of population regulation. The tendency for species in such ecosystems to be regulated under 'K' selection, where a balance is maintained in birth and death rates, ensures that, at any given point, productivity remains relatively stable (Gamble 1978: 155).

b) Specialized ecosystems

Occurring in high latitudes, specialized ecosystems are subject to marked variations in the availability and amount of incoming solar radiation. Furthermore, in comparison with low latitude environments specialized ecosystems receive considerably reduced quantities of solar radiation. Using Bailey's (1960) measure of the amount and annual distribution of incoming solar radiation - 'effective temperature' - polar environments derive a value of 8°C compared with 26°C for tropical environments (Binford 1980: 14).

Consequently, in addition to exhibiting seasonally structured variations the net above-ground primary productivity of specialized environments tends to be markedly lower than is the case with environments in lower latitudes. From the examples cited by Harris (1969: 5) the net above-ground primary productivity for arctic tundra (c. 365 $gm/m^2/yr.$), mid-latitude grasslands (c. 183 - 730 $gm/m^2/yr.$) and the boreal forest (c. 183 - 730 $gm/m^2/yr.$) contrasts with the productivity of generalized low latitude environments.

The reduced quantity and stability of productivity is compounded by the low species diversity of specialized environments. Gamble (1978: 155) has noted that whilst species diversity tends to be low individual species may attain large numbers and come to dominate the ecosystem. Under such conditions the normal functioning and productivity of the ecosystem may be dependent upon a few species and, consequently, vulnerable to variations in their numbers. Such inherent instability is further enhanced through the tendency for species in specialized environments to regulate their numbers through 'r' selection strategies which produce dramatic variations in population numbers through time.

The tendency for certain mobile species in specialized ecosystems to undertake seasonal long-distance migrations as a response to the spatial and temporal variability of the environment adds a further dimension to variations in productivity. Most notable are the barren grounds caribou (Rangifer tarandus) and elk (Cervus canadensis) (Orr 1970), whose migrations involve the aggregation, on occasion, of thousands of individuals and their wholesale movement over hundreds of kilometres. In other cases altitudinal migrations may achieve the same ends whilst reducing the actual distances covered.

Summary

The net effect of these very different conditions of ecosystem structural and functional complexity is to produce markedly different patterns of productivity and stability. Arising from this, we can see that the exploitational strategies of hunter-gatherers occupying these different ecosystem types are confronted with two differing sets of problems concerning resource acquisition. In generalized environments hunter-gatherers develop strategies designed to cope with the exploitation of stable, diverse resources that are subject to relatively minor variations in productivity.

In contrast, hunter-gatherers occupying specialized environments must develop strategies designed to cope with the combined effects of low species diversity, highly seasonal productivity and high instability in production. In examining the specific details of exploitational strategies as responses to these polarized sets of resource acquisition problems it is possible to identify the contrasting adaptational responses of hunter-gatherers and account for much of the diversity exhibited in their subsistence, mobility and scheduling behaviour.

1) Costs and risks

Prior to discussing the details of hunter-gatherer adaptations as responses to resource acquisition problems it is necessary to identify the principal objectives guiding exploitation strategies. Jochim (1976) has discussed the various objectives, or 'goals', which guide hunter-gatherer resource use. From his discussion two primary objectives were identified:

> (1) 'The attainment of a secure level of food and manufacturing needs',

and,

> (2) 'The maintenance of energy expenditure within a predefined range'.
>
> (19).

Discussions of hunter-gatherer subsistence behaviour have frequently emphasized the two guiding principles, the minimization of risk and energy expenditure, in the economic decision-making of contemporary groups (Lee 1968, 1969; Oberg 1973: 65; Paine 1973). Consideration of these two interrelated principles provides us with an important insight into the variability which hunter-gatherers exhibit in their subsistence and settlement strategies.

The level of risk and cost associated with the exploitation of a given resource can be assessed through the consideration of the specific characteristics pertaining to that resource. To assist us in that assessment we can use the following measures developed in ecological research into foraging behaviour (MacArthur and Pianka 1966; Schoener 1971):

a) Search time: the amount of time required in locating a resource.

b) Pursuit time: the amount of time which elapses between the initial locating and eventual capture of a resource.

c) Handling costs: measured in either time or energy expenditure, the costs can be subdivided into

c i) Retrieval costs: being the costs incurred after capture in securing and/or transporting the resource.

c ii) Processing costs: being the costs of transforming a resource into an edible or useable form.

In an article tracing the importance of energetic efficiency models in anthropological research Smith (1979) has emphasized the role which such approaches have played in the growth of general theory connected with hunter-gatherer subsistence and settlement. Energetic efficiency models have informed research addressing foraging behaviour (Harpending and Davis 1977; Hill and Hawkes 1983; Lee 1969; O'Connell and Hawkes 1984; Reidhead 1980; Winterhalder and Smith 1980; Yellen and Harpending 1972) and the spatial implications of differing subsistence strategies (Jochim 1976; Wilmsen 1973).

Whereas much of this research has emphasized the quantity of energy capture Smith (op. cit.) has proposed the theoretical value of considering the rate of energy capture as a primary adaptive constraint.

In discussing the roles of cost and risk minimization strategies of hunter-gatherers we need to consider not only the overall quantity of energy return, but also the rate or speed of energy return. The above measures provide us with useful parameters for examining these variables in the exploitation of differing kinds of resources.

Two of the most critical variables concerning the calculation of risk and cost associated with resource exploitation are the resource mobility and resource population density. As noted by Jochim (1976),

> 'risk decreases as the density increases and as mobility decreases',

whilst,

> 'A resource is less expensive ... the greater its unit yield (weight, non-food yield) and its aggregation size, and the less its mobility.'
>
> (25).

Other things being equal, therefore, the degree of risk and cost associated with the exploitation of a given resource will vary according to the level of resource aggregation, or the degree of prey mobility. This is derived from the observation that as overall resource density increases then, so too, the probability of encountering the resource increases (Keene 1981: 26), whilst increased prey mobility will increase the chances of its escape.

Given the primary adaptive goals of minimizing risk and cost we can see that opportunities for exploiting a given resource under conditions of reduced mobility or increased aggregation should be favoured. The following account of Waswanapi hunting strategies serves to illustrate the importance of prey mobility and aggregation.

> 'During the early winter as the snow accumulates the moose begin to have trouble walking through deep snow .... Moose, therefore, move to locations that have relatively lower snow accumulations.... By early January such conditions have normally occurred, the moose are concentrated in these suitable areas .... Once this has happened hunters say it is easy to hunt moose.'
>
> (Feit 1973: 119).

The essential points here concern the exploitation of a mobile resource. When exploiting mobile resources under conditions where the resource population is dispersed hunters must spend time and energy in locating the resource. As a result the investment in search time can be high with little guarantee of success, incurring a higher risk of failure. Once located, the mobility of the resource demands further investments of time and energy in pursuing with, once again, no guarantee of success in capture.

From this we can see that the exploitation of dispersed mobile resources demands potentially high investments in search and pursuit time with high risks of failure. Under these conditions the exploitation of mobile, dispersed resources is a 'high-risk' activity (Lee 1968: 40).

As illustrated above, the Waswanapi reduce the risks and costs of hunting by taking advantage of conditions under which resource mobility is reduced and the level of aggregation is high. To achieve this they employ their detailed knowledge of regional topography, vegetational cover and resource behaviour in order to predict the timing and location of conditions favourable for resource aggregation. In this way investments of time and energy in search and pursuit are reduced thereby allowing more time and energy to be expended, in the event of initial failure, in locating and capturing alternative prey. Such a strategy serves to reduce the overall risks of failure. The ability to employ such a strategy can be seen to be related to the degree in which opportunities for capitalizing upon favourable conditions of resource density and/or mobility may be anticipated.

The exploitation of non-mobile resources presents us with a contrasting set of conditions to consider. Resources that are sedentary, such as plant foods or certain shellfish species, clearly do not require investments of time or energy during exploitation in being pursued. Furthermore, many non-mobile resources will tend to maintain their distribution in a landscape from week to week or even over years. Consequently, a knowledge of the location of previously exploited resources may, in many instances, prove sufficient for the effective reduction in time and energy investments in locating. However, the density of non-mobile resources may exert limiting constraints upon their exploitation by increasing or decreasing the time and energy required for gathering adequate quantities. Silberbauer (1972), for example, has described the limiting effects of a sparse distribution upon search time in the exploitation of ostrich eggs by the G/Wi (284). As the population density of non-mobile resources decreases increased investments in search time must be made in order to procure adequate resources. From this it follows that the time required will be 'less for (those resources) ... exhibiting clumped or aggregated rather than dispersed distribution patterns.' (Keene 1981: 28). From this we can also see that the exploitation of non-mobile resources may incur increasing costs as a local resource population is depleted and 'thinned-out' by repeated gathering. This latter consideration will be seen to be significant when we turn to consider hunter-gatherer settlement patterns.

In general terms, however, the exploitation of non-mobile resources can be regarded as contrasting, in terms of levels of risk, with the exploitation of mobile prey. Non-mobile resources represent a relatively low risk target for exploitation since they cannot escape once located. In terms of costs, however, the exploitation of sedentary resources can and does exert a limiting effect. Non-mobile resources, such as nuts, tubers, berries or shellfish, frequently occur in relatively small unit sizes. The size of individual resource-units influences the rate at which they may be gathered. On the basis of experimental studies Perlman (1980) has demonstrated the differential costs of exploiting non-mobile resources with respect to various unit sizes (279). From Perlman's study it is clear that, for example, the exploitation of small versus large acorns is less productive per unit-time. The costs incurred in gathering non-mobile resources may be limited by the selection of larger individuals or species. The adoption of a size-selective exploitation strategy from within a population exhibiting a normally distributed size range will, however, incur additional time costs in comparison with a random selection strategy.

Additional costs are associated with exploiting non-mobile resources through the wastage of time and energy in gathering and handling small resource units with a high ratio of inedible to edible weight. As a percentage of the total weight, for example, the edible weight of oysters is only 11.8%, mussels 28%, scallops 18% and periwinkles 22% (Reay et al. 1946). These figures contrast with approximate values for the percentage of edible weight for cervids and bovides of 60%, and of 75% for pigs. The high proportion of inedible weight places further demands upon exploitation by requiring the processing of large numbers of small resource units in order to produce an edible form. As discussed by Keene (1981: 71 - 91) the processing of nuts can involve many stages (hulling, shelling, crushing, grinding, boiling or leaching). Each stage demands time and energy thereby contributing to the overall costs of exploitation.

The exploitation of non-mobile resources represents a low risk activity but the costs associated with the various stages of handling can be very high. Given the effects upon search time of the progressive exploitation of non-mobile resource population densities we can see that handling costs, in terms of transporting resources, will also increase with prolonged exploitation. These combined cost considerations can be expected to exert constraints upon exploitation strategies. A heavy dependency upon non-mobile resources will demand a balance between the benefits of using low-risk resources and the high costs of handling.

Having briefly contrasted the relative costs and risks associated with the exploitation of mobile versus non-mobile resources it is possible to recognize that the dependency of strategies upon differing resource types will exhibit differing degrees of concern with risk and cost minimization. The exploitation of mobile resources is essentially a high-risk activity. The risks of failure can be limited, in part, through the adoption of strategies which seek to improve efficiency in locating and capturing resources. Non-mobile resources, on the other hand, represent a low-risk activity, but the costs of handling can be expected to exert a constraining influence upon exploitation. If we turn to consider the strategies of hunter-gatherers living under differing conditions of environmental resource structuring the implications of the relative dependency upon mobile versus non-mobile resources can be seen to constrain, in part, the mobility and scheduling behaviour of groups.

2) Mobility and scheduling

As perspectives of hunter-gatherer subsistence behaviour have changed, then, so too, our understanding of relationships between environmental resource structuring and the mobility strategies of hunter-gatherers has seen rapid developments. It has long been acknowledged, by archaeologists and ethnographers alike, that the mobility strategies of hunter-gatherers are responses to variations in the abundance and availability of environmental resources. However, as recognized by Binford (1980: 13), many discussions have failed to appreciate the specific characteristics of environmental resource structure and how they relate to hunter-gatherer mobility strategies. The tendency to characterize environments as either resource rich or poor has served to limit perspectives concerning the mobility of hunter-gatherers (c.f. Kelly 1983: 279).

Recently, the work of Binford (1978b, 1980, 1982) and Kelly (1983) has directly addressed the relationships between mobility, subsistence and the structure of environmental resources. In his analysis of contemporary hunter-gatherer behaviour Binford (1980) has drawn a distinction between residential and logistical mobility. Residential mobility refers to the movement of all of the members of one residential site to another site. Logistical mobility refers to the movement of individuals, or a group of individuals away from the residential site in response to the need to undertake specific tasks at distance from the residential site. Logistically based movement can frequently involve the task group being away from the residential site for extended periods. The distinction between logistical and residential mobility allows us to examine the ways in which hunter-gatherers in different environmental settings organize themselves in the procurement of resources.

Binford's analysis of the behaviour of hunter-gatherers focussed attention upon two polarized types of subsistence settlement strategy. Binford designated these two types as a)foragers, and b)collectors (1980: 5). In the discussion of these two types of adaptation the relative dependence upon residential versus logistical mobility is deliberately contrasted. Importantly, however, as emphasized by both Binford and Kelly (1983: 278), residential and logistical mobility should not be regarded as mutually exclusive responses. Rather, they are 'organizational alternatives which may be employed in varying mixes in different settings.' (Binford 1980: 19).

a) Forager strategies

Forager strategies characteristically involve the procurement and consumption of food resources on a day-to-day basis, with little or no storage of foods from one day to the next. In Binford's words, foragers 'range out gathering food on an "encounter" basis and return to their residential bases each afternoon or evening.' (5). Consequently, forager residence sites are positioned within an immediate foraging area from which the occupants of the site obtain their resources.

Forager strategies can be recognized from hunter-gatherers occupying environments which offer certain conditions in the spatial and temporal organization of resources. In tropical rainforests and other equatorial environments the spatial and temporal organization of resources may be largely undifferentiated. We have previously discussed the relative seasonal stability of productivity in generalized environments as a reflection of the annual distribution and quantity of solar radiation. In generalized ecosystems, such as are found in equatorial rainforests, the combined effects of high species diversity, net primary productivity and stability, with spatially undifferentiated resources serve to promote the adoption of forager strategies amongst hunter-gatherers.

Although individual species may exhibit seasonal variations in their productivity, the 'interdigitation of differing schedules (of productivity) among species ensures that there will be continuously available foods.' (Binford 1980: 15).

Under such circumstances the spatial and temporal distributions of both mobile and non-mobile resources tend to be even, exhibiting low levels of aggregation. As previously discussed, the exploitation of mobile resources under conditions of population dispersal, where the movements of animals are less predictable, would incur relatively high investments of time and energy in locating and pursuing them with a high level of risk of failure. In contrast, the exploitation of non-mobile resources might also incur high costs in searching for adequate quantities and in handling them subsequent to retrieval, but this is achieved with relatively low risks of failure. Consequently, foragers seek to minimize the risks of failure in resource acquisition by emphasizing the exploitation of non-mobile resources. In addition, the costs associated with the exploitation of non-mobile resources are reduced, or kept within acceptable limits, through the limitation of the distance which resources are transported and by ensuring that the costs of locating resources do not rise beyond certain levels. As the resources within the immediate vicinity, or foraging radius (Binford 1980: 5), around the settlement site are depleted the time and energy required to procure an adequate level of resources increase. As a result, food gathering is undertaken at increasing distance from the residence site, increasing search time and transportation costs. There comes a point where the increasing costs of searching and transportation exceed those incurred in relocating the residence site in a new, unexploited resource area (fig. 1). As a result, forager strategies characteristically involve frequent residential moves during an annual cycle as consumers are moved to new resource areas. Poiner (1976), in discussing the

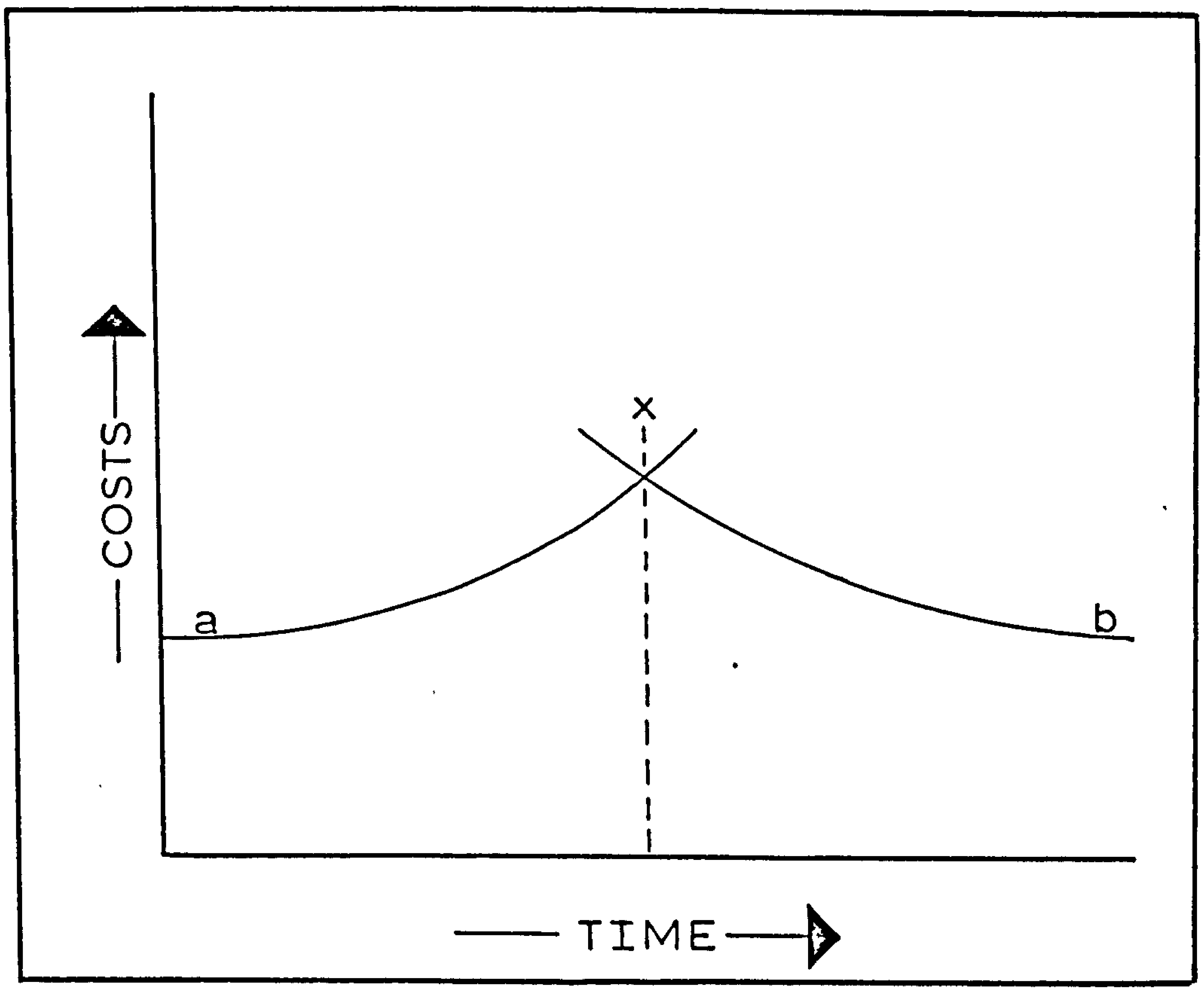

COSTS
x
a
b
TIME

fig.1

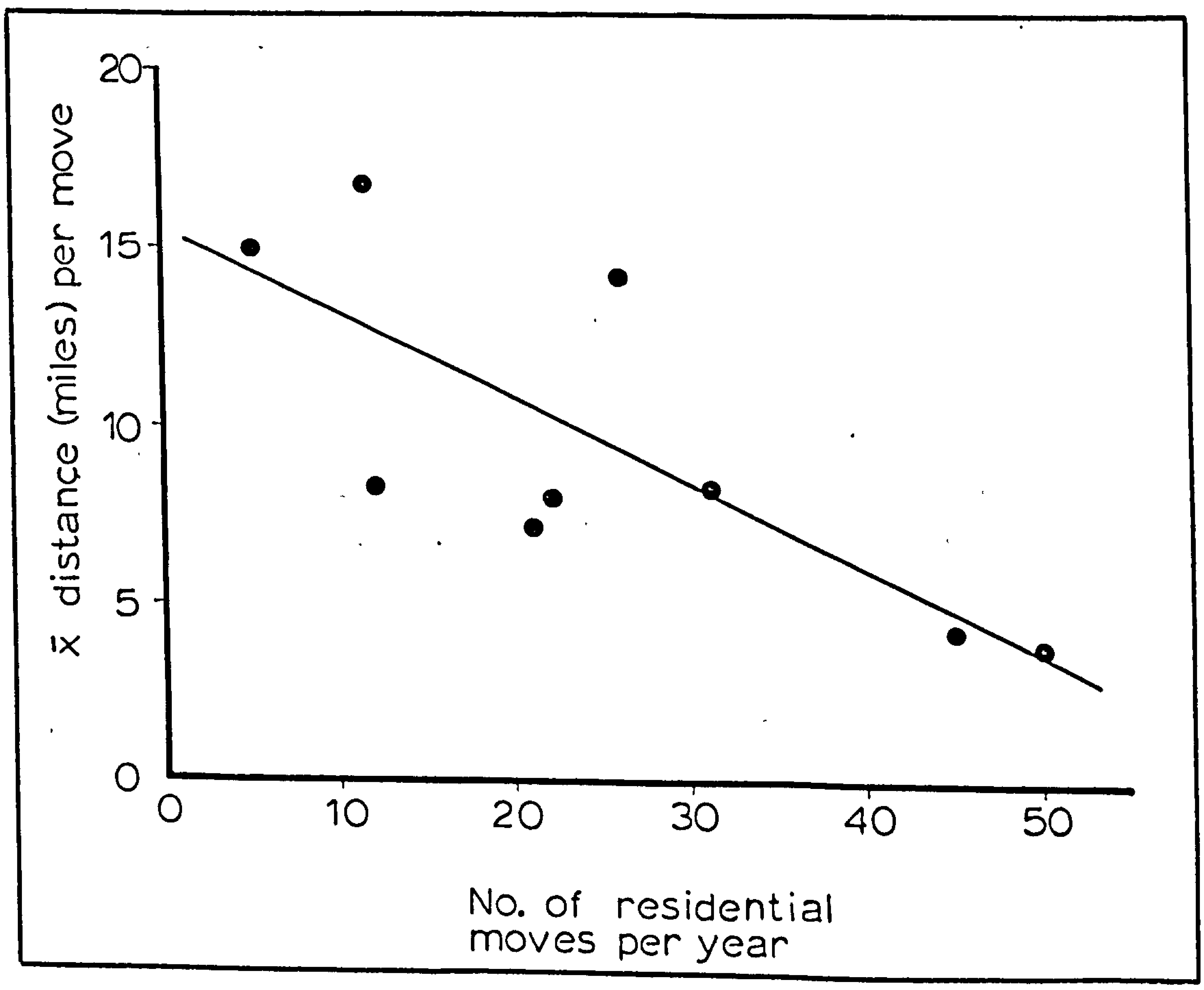

20
15
10
5
0
x̄ distance (miles) per move
0
10
20
30
40
50
No. of residential moves per year

fig.2

subsistence mobility behaviour of foragers in New South Wales, has recognized the impact of increasing costs of resource procurement upon mobility. He notes that,

> '... a diminution of resources in both quantity and range ... suggests more frequent movement of groups as a response to more distant daily excursions.'
>
> (192).

The absolute number of residential moves undertaken by any specific foraging group is dependent upon the overall density of resources, the level of resource demand (calculated on the food requirements of the total number of individuals in a residence site), and the resulting rate of resource depletion within an exploited area (Carlstein 1982: 80 - 82). In environments where resources are relatively scarce and dispersed, as Binford has noted,

> 'the size of the mobile group may be reduced and these small units scattered over a large area, each exploiting an extended foraging radius.'
>
> (1980: 7).

By comparison, areas with relatively high levels of overall resource density may be exploited by larger mobile groups, increasing residential mobility with inter-settlement distance reduced. We can see (fig. 2) that for equatorial and sub-equatorial foragers the importance of limiting costs maintains a close relationship between the number and average distance of residential moves ($r = -0.75$: $p < .001$) over an annual cycle.

Forager strategies can be recognized as operating amongst hunter-gatherers living in environments which differ in terms of the spatial arrangement of resources from the undifferentiated contexts thus far considered. As Binford (1980: 5) has indicated, similar strategies may be equally appropriate in environments where resources occur together in a series of discrete patches. Under these conditions residence sites are moved from one resource patch to another, possibly resulting in an increased inter-settlement distance.

Similarly, the distribution of critical resources may serve to constrain the number of alternative residence locations. In low latitude arid environments the availability of water may be limited to a series of discrete water holes during the dry season. Consequently, forager residences may be positioned with regard to the water supplies. As Binford (1980: 7) has observed,

> 'Such spatial discreteness tends to "tie-down" the settlement system to specific geographical areas while other areas would be occupied little and rarely used because of their distance from such limited and crucial resources.'.

Concerning the applicability of forager strategies, the crucial factor is the availability of the necessary, critical resources for exploitation, at any given time of the year, within the foraging radii of a series of residence sites. Under these conditions in the temporal and spatial structuring of resources groups can maintain an even and steady input of the necessary resources through the periodic relocation of the residence site. In this way forager subsistence schedules maintain a relatively regular level of resource procurement activity throughout the year. The availability of a variety of low-risk resources at all times of the year serves to minimize the need to plan subsistence activities far in advance. Variations in the density of resources can be accommodated through adjustments in the size of the residential group, the duration of occupation, and in the distances between residential sites.

b) Collector strategies

Collector strategies characteristically involve the storage of food for at least part of the year, and the procurement of food resources through the organization of task groups using logistical mobility. The use of logistical mobility is primarily a response to conditions where critical resources are spatially discrete and distant from one another. As stated by Binford,

> 'Logistical strategies are labour accommodations to incongruent distributions or conditions which otherwise restrict mobility. Put another way, they are accommodations to the situation where consumers are near to one critical resource but far from another equally critical resource.'
>
> (1980: 10).

Logistically organized task groups integrate spatially incongruous resources in contexts where residential mobility, of itself, cannot solve the problems of resource acquisition. Where two or more resources are essential, but do not occur together, a collector residence site may be located to provide easy access to one, and the other resources will be obtained through the use of task groups. The decision as to which resource will influence the location of the residential site depends upon an assessment of the bulk costs of transporting the different resources. In the case of the Nunamiut, for example, the demand for fuel is the overriding factor in determining the winter residence site, because 'firewood is the single largest bulk resource needed during winter.' (Binford 1978a: 425).

As previously discussed, we can relate variations in the degree of stability and productivity of ecosystems to global patterns in the quantity and annual distribution of solar radiation. In higher latitude environments the increased seasonality of productivity is associated with a reduced quantity of primary production. Consequently, hunter-gatherers occupying higher latitude environments must cope with the exploitation of resources in contexts of seasonally structured and reduced levels of primary production. As a result, the availability of low-risk, non-mobile resources tends to be temporally restricted to a short growing season. For the rest of the year hunter-gatherers are obliged to focus their exploitational activities upon a variety of mobile resources. In our discussion of specialized environments we recognized that species diversity tends to be low, although certain species may attain large numbers. From this, we can see that as we move from generalized environments in low latitudes to more specialized environments in higher latitudes hunter-gatherers will be increasingly dependent upon a limited range of mobile resources.

One of the implications of the latitudinal gradient of species diversity is that hunter-gatherers in higher latitude environments will be confronted with the task of exploiting resources that are critical to their survival. Furthermore, given the reduced species diversity and mobile nature of the critical resources we can see that the probability of incongruency in the spatial distribution of critical resources will increase (Binford 1980: 15). Dependence upon logistical mobility as a means of integrating spatially incongruous critical resources can, therefore, be expected to increase with greater seasonal variations in the thermal environment (Binford 1980: 15).

The strategies of hunter-gatherers living in higher latitude environments are designed to procure mobile resources without the added insurance of non-mobile, low-risk resources as a back-up when the strategy fails. Consequently, the success of the strategy is essential to the survival of the group. We previously identified the hunting strategies of the Waswanapi, and recognized the importance of opportunities for exploiting resources when resource density is increased or mobility reduced (Kelly 1983: 289). Central to their ability to capitalize upon favourable hunting conditions is the detailed knowledge of the timing and location of resource aggregations exhibiting reduced mobility. By taking advantage of these conditions the Waswanapi reduce the amount of search-time required, and reduce the level of risk associated with exploiting mobile resources.

Binford (1978a: 169 - 178) has discussed the hunting strategies of groups living in seasonally structured environments and has identified two general types of strategy. Encounter strategies are those employed when resources are relatively dispersed and/or less predictable in their occurrence. Hunters, usually in small groups, spend time searching for their prey, and may move between a number of locations before encountering resources. Intercept strategies, on the other hand, involve hunters, sometimes in large groups, positioning themselves in a specific location and waiting for game to appear. The latter strategy is usually associated with the main migration periods of mobile species when resources are maximally aggregated, or when, as with the Waswanapi case, the species adjusts its range and population density as a response to adverse conditions. Intercept strategies are particularly dependent upon the ability of hunters to anticipate the behavioural characteristics of a species in order to predict the timing and location of occurrence.

Whilst all hunter-gatherers may employ an encounter strategy for hunting at various times of the year intercept strategies can assume a particularly important role for higher latitude groups. The increased seasonality of high latitude environments presents hunter-gatherers with the problems of 'over-wintering'. Given that hunting is, under conditions of dispersed resource populations, a high-risk activity, the ability to capitalize upon periods of resource aggregation presents certain high latitude hunter-gatherers with an opportunity to amass large quantities of resources in a short period and to accumulate stores of resources as a basis for solving the problems of over-wintering.

In order that the procurement of mobile resources, either through encounter or intercept strategies, involves as little risk of failure as possible collectors plan their subsistence activities well ahead of their implementation. This latter point is crucial to an understanding of the nature of logistical mobility strategies. Whereas foragers move out from residence sites and may procure resources as they are found, collectors plan task group mobility in anticipation of undertaking specific tasks at particular locations. Through detailed scheduling of activities hunter-gatherers in high latitudes can ensure that time is not wasted when there is a need for efficiency in subsistence activities. If this is true for high latitude hunter-gatherers in general, then it is especially important for those groups who put up stores for the winter period.

Just as logistical mobility represents a response to the incongruent spatial distribution of resources, storage represents a response to incongruency in the temporal availability of resources. Temporal incongruency in critical resource availability can also be correlated with increasing seasonality in environments. Binford (1980: 16) has demonstrated that the degree of storage dependence amongst contemporary hunter-gatherers correlates with decreasing values of effective temperature. Storage strategies serve to extend the utility of a resource beyond the period when they are most readily obtained in the environment (Binford 1980: 15 - 16).

However, the degree of storage dependence places further constraints upon mobility strategies. The localized accumulation of bulk resources serves to commit the overall mobility strategy to the transportation of these resources, through the use of task groups, back to the residence site (c.f. Carlstein 1982: 67 - 69). In other words,

> 'Storage reduces incongruous temporal phasing of resources, but it may increase the problem of spatial incongruity.'
>
> (Binford 1980: 15).

Consequently, we can expect that as the use of storage strategies increases there will be a decrease in the role of residential mobility in favour of increased use of logistical task group mobility. Furthermore, given the role of storage as a response to temporal incongruency we can expect that as environments increase in seasonal variability hunter-gatherers will exhibit an increasing dependence upon storage and logistical mobility (Binford 1980: 15).

c) Serial specialists

In analyzing the level of storage dependence amongst contemporary hunter-gatherers Binford (1980: 17) identified an alternative set of strategies amongst certain high-latitude groups who do not exhibit a heavy dependence upon stored foods. These groups, designated as serial specialists, occupy environments where the temporal and spatial structuring of resources is such that residential mobility can be used effectively to position consumers close to critical resources throughout the year. Consequently, storage plays only a minor role in their subsistence schedule. From the example of Copper eskimo food procurement scheduling, as discussed by Damas (1972), we can see (fig. 3) that throughout the year specific resources assume a critical role in exploitation, and that only during November do the Copper eskimo utilize stored resources. During November the stored foods are supplemented by secondary procurement activities.

Whilst the relative dependence upon residential mobility implies a closer relationship to forager rather than collector strategies there are clear grounds for regarding serial specialists separately. Whereas foragers exploit a range of low-risk resources at any given time of the year, serial specialists focus their exploitation upon specific mobile resources at different times of the year. Consequently, the resource schedule of serial specialists is still designed for efficiency in the exploitation of high-risk resources without the facility of low-risk resources as an alternative response.

The need for efficiency in the exploitation of resources is partly met by the utilization of knowledge concerning the distribution of resources. Unlike classic forager strategists serial specialists move their residence sites long distances between specific locations as and when resources become most amenable to exploitation. In this sense, serial specialists hold more in common with the mobility strategies of foragers in environments where the distribution of critical resources is restricted to a few locations. The problems of over-wintering are solved by the continued exploitation of resources that have, themselves, solved the problems of over-wintering (c.f. Binford 1980: 15).

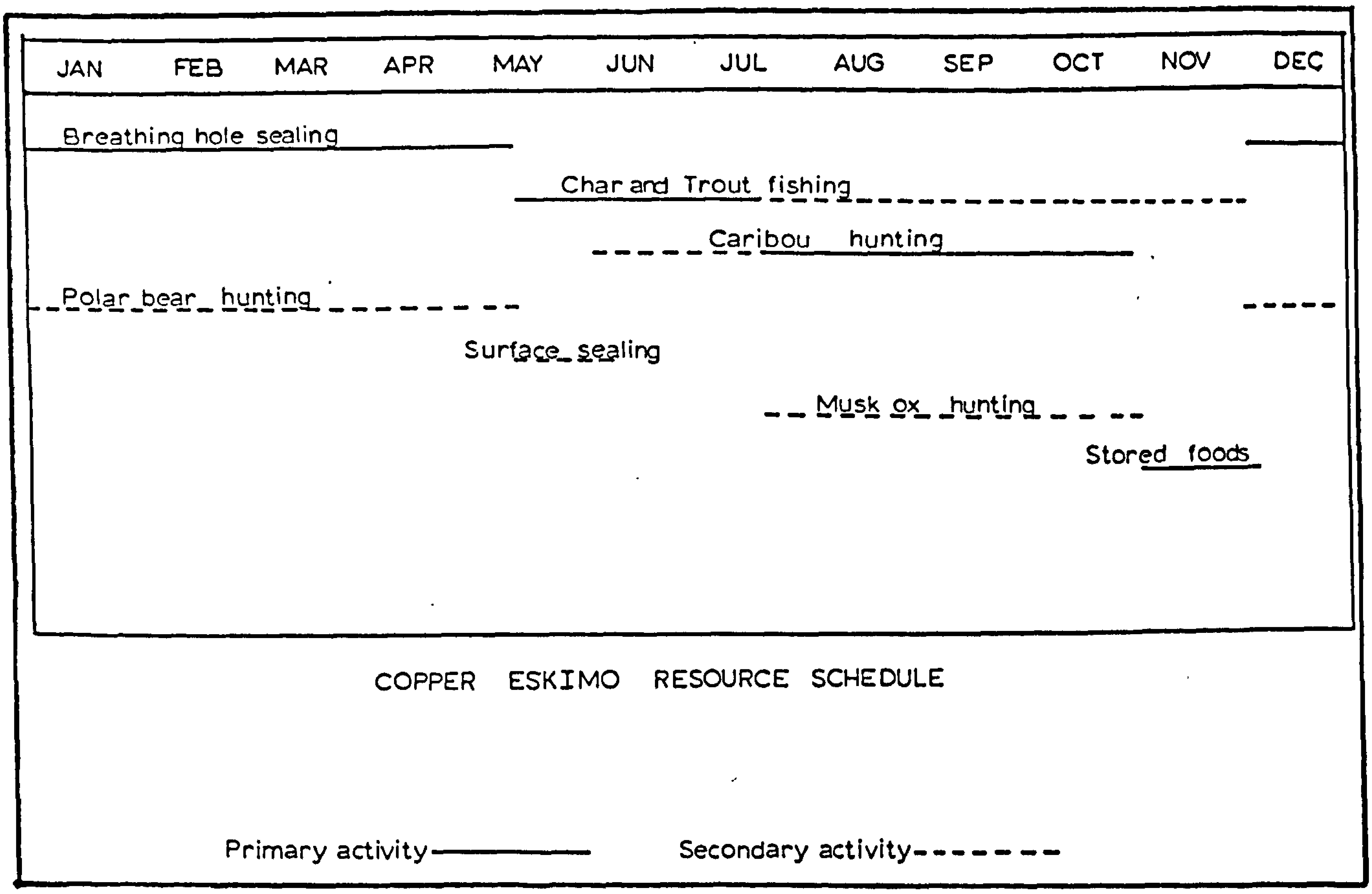

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Breathing hole sealing
Char and Trout fishing
Caribou hunting
Polar bear hunting
Surface sealing
Musk ox hunting
Stored foods
COPPER ESKIMO RESOURCE SCHEDULE
Primary activity
Secondary activity

fig.3

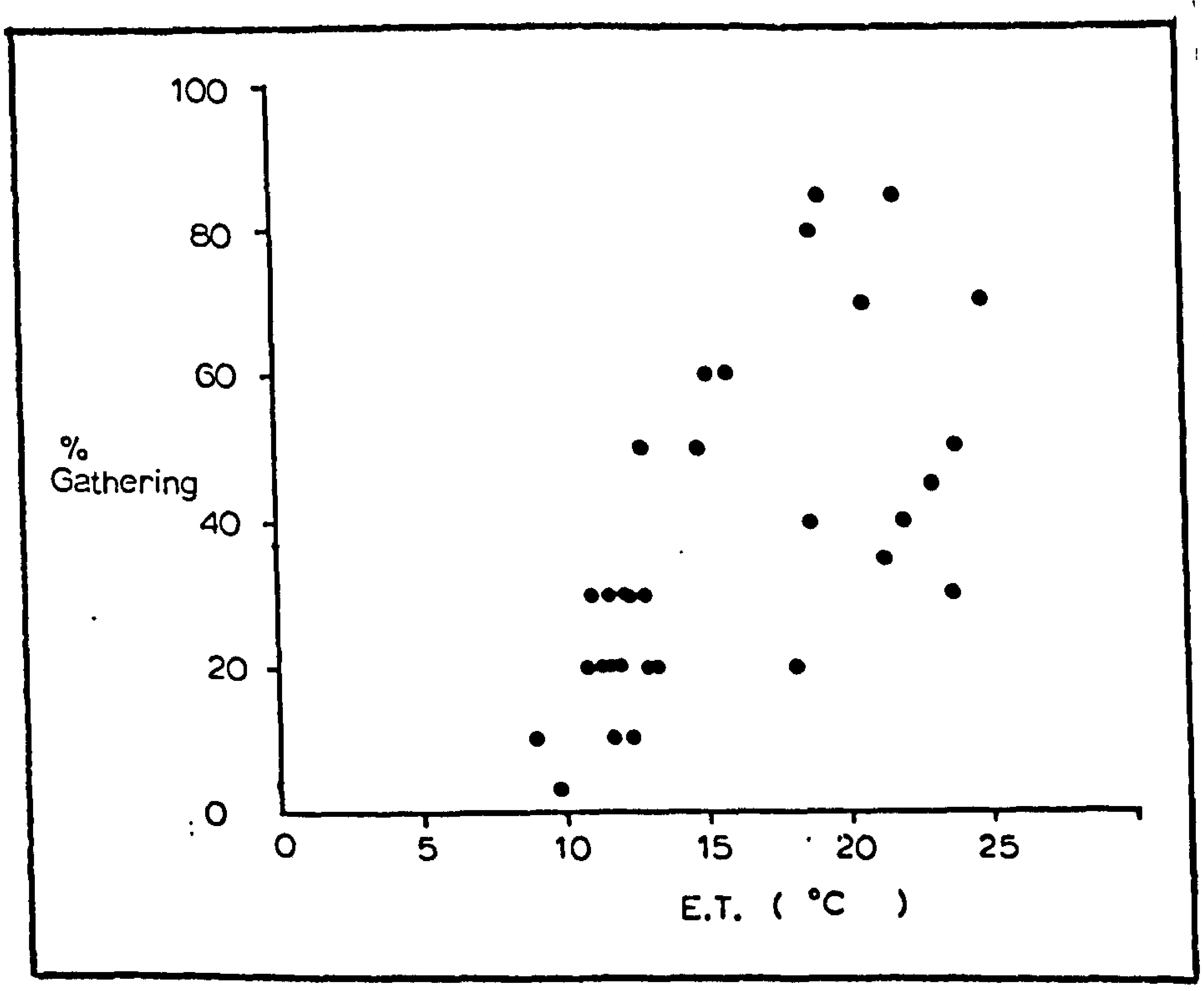

100
80
60
40
20
0
% Gathering
0
5
10
15
20
25
E.T. (°C)

fig.4

Discussion

The recognition that the mobility and subsistence scheduling of hunter-gatherers is responsive to conditions other than simple patterns of food abundance (c.f. Binford 1980: 14) is crucial to the development of our understanding of hunter-gatherer behaviour. The analysis of mobility strategies in terms of the differential roles of residential and logistical mobility, combined with an appreciation of how storage strategies operate, enables us to identify some of the crucial factors responsible for the diversity in contemporary hunter-gatherer economic behaviour. In particular, we can see how hunter-gatherers operating forager strategies differ, both spatially and temporally, in their organization of food procurement and the minimization of costs and risks when compared with collectors.

Forager strategies are primarily limited by the costs of exploiting relatively undifferentiated resources. In seeking to limit costs foragers, exploiting a diverse range of resources, execute residential mobility and thereby minimize the energy expended in locating and handling resources. The low level of temporal variation in forager environments, combined with high primary biomass, ensures that throughout the year they have access to a variety of low-risk resources. As a result, food procurement activities are evenly scheduled over the course of the year producing a steady input of low-risk resources. In the event of increased demand, or locally reduced productivity or density, foragers can access their required resources through additional energy expenditure in procuring further resources. From this we can say that foragers are primarily limited by the availability of energy for food procurement.

In contrast, collector strategies are characteristically found in environments where temporal or spatial incongruency introduces specific cost and risk demands. The low species diversity, and seasonally variable availability of resources, combined with a low-level and seasonally structured primary biomass production produces amongst collectors strategic responses to cope with the exploitation of high-risk, time consuming mobile resources. Collector strategies are, therefore, primarily constrained by the need to minimize risk through the efficient use of time. The contrast between energy-stressed forager strategies and time-stressed collector strategies is reflected in the levels of planning and anticipatory behaviour related to subsistence activities.

Collector strategies reflect the need to minimize risk of failure in the procurement of critical, mobile resources. The scheduling of exploitation amongst collectors differs from that found in foraging societies in that specific resources are exploited at particular times of the year, with favourable conditions of resource accessibility being used to provide resources for storage. This sort of scheduling behaviour is planned, with task groups (or, as in the case of serial specialists, residential groups) moving to known locations in order to obtain specific resources. Failure to obtain sufficient resources under such conditions has potentially disastrous consequences for the group as a whole. Without the facility to exploit low-risk, non-mobile resources the survival of the group is dependent upon the success of the strategy. Additional inputs of energy will not, of itself, guarantee success, since the crucial factor determining success is the ability of such groups to locate and capture resources through a detailed knowledge of resource behaviour. In the event of failure in the capacity to accurately predict resource occurrence the time wasted will, in turn, place an even higher level of stress upon locating and capturing alternative resources. We can see that any failure or short-fall in procuring resources for over-wintering will threaten the group with food shortage, and possibly starvation. Consequently, collector strategies have to be highly efficient in the monitoring of resource availability, the scheduling of resource exploitation, and in the actual performance of procuring resources.

Between the poles of generalized and specialized environments, of forager and collector strategies, we can expect a variety of hunter-gatherer adaptive responses combining, in various mixes, the organizational characteristics associated with the adaptational extremes. It is possible, however, to recognize general trends in the balance of strategic responses to resource procurement challenges at a global level. The correlation between seasonal variability and food procurement activities can be demonstrated (fig. 4), using estimates of the percentage contribution of gathered (non-mobile) resources against the effective temperature measure of environmental variability ($r = 0.6302 : p < .001$). This compares favourably with the correlation between percentage dependence upon hunting and latitude found by Foley (1982: 394).

Whilst all hunter-gatherer systems can be expected to exhibit some of the characteristics of foraging adaptations the degree of dependence upon logistical strategies will vary according to levels of spatial or temporal incongruency in the resource environment. As the degree of seasonal variability in temperture regimes increases we can expect a concomitant increase in logistical responses (Binford 1980: 15). Since the length of the growing season is inversely proportional to increases in latitude we can see that the problems of over-wintering will increase as we move from low to high latitudes. In seeking to cope with the over-wintering problem hunter-gatherers may employ logistical strategies, but the form which those strategies take will be largely dependent upon the specific behavioural characteristics of target resources. For example, in temperate latitudes the responses of animal resource populations may not incorporate a large-scale migratory response to the onset of winter, but may result in a series of relatively small-scale adjustments which do not significantly increase local resource population aggregation levels. Under these conditions hunter-gatherers may remain active in hunting resources during the winter period, instead of attempting to accumulate a surplus for over-wintering (Binford 1980: 15). Such a response, whilst exhibiting a low level of storage dependence, would demand a highly efficient hunting strategy.

In other situations, groups may be able to solve the problems of over-wintering, at least in part, by storing durable non-mobile resources from the end of the growing season. This would be a feasible response if, during the autumn, non-mobile resources could be efficiently gathered in sufficient quantity without unreasonable expenditure of energy. The bulk storage of resources would, however, serve to constrain residential mobility and promote an increased dependence upon logistical task group mobility. In situations where non-mobile resources remain available for exploitation during the winter, as may be the case with inter-tidal shellfish, groups may concentrate their exploitation of those resources during the winter months. Once again, such a strategy would effectively constrain residential mobility to those coastal areas where inter-tidal resources could be efficiently exploited. Furthermore, the prolonged exploitation of a sedentary resource population which is spatially restricted might result in long-term reductions in the productivity of the resource, thereby increasing the risks and costs associated with continued exploitation (Gray and Yesner 1978; Yesner 1977: 24).

The contrasting mobility and scheduling behaviour of energy-stressed foragers and time-stressed collectors carries a variety of implications for the formation of the archaeological record of hunter-gatherers. In the following sections attention will be drawn to the implications of forager and collector strategies for structuring in the archaeological record.

The organizational and structural dimensions of technology

Introduction

The contrasting behavioural characteristics of forager and collector systems have important implications for archaeological formation processes and structuring in the archaeological record. In the following sections attention will be focussed upon the implications of energy-stressed and time-stressed systems of mobility and scheduling behaviour for the analysis of hunter-gatherer technology. Particular emphasis will be given to the organizational and structural dimensions of lithic technology. The organizational dimensions of lithic technology encompass lithic procurement, manufacture, repair/maintenance and resulting patterns of discard for technological products and by-products. The structural dimensions of lithic technology encompass tool assemblage composition, diversity and complexity. The principal aim is to identify approaches which might be employed by lithic analysts in seeking to discuss prehistoric mobility and scheduling behaviour through analyses of lithic assemblages. Initially, some of the contrasting implications of differing hunter-gatherer scheduling and mobility strategies for site formation will be discussed.

1) Implications for site formation

The differing strategic responses of hunter-gatherers have significant implications for the formation of the archaeological record. In particular, the increased dependence upon logistic mobility and storage strategies introduces a structural diversity and complexity into the range of sites generated by hunter-gatherers which influences the level of archaeological visibility of hunter-gatherer systems.

Foragers, in maintaining a steady input of resources on a daily basis, do not generally need to spend extended periods away from residence sites during the course of procurement activities. As a result they tend to generate two types of site, the residence and the location (Binford 1980: 9). Residence sites provide the focus for sleeping, eating, socializing and maintenance activities. Since foragers return to residence sites each day with the resources required for immediate consumption the level of debris generated at these sites can be demonstrated to be a function of the level of consumer demand (i.e. the number of individuals at the residence) and the duration of occupation (Binford 1978b: 357 - 359; Yellen 1977).

The archaeological visibility of forager residence sites is also determined by the regularity of site re-occupation on a year to year basis. In classic forager systems, such as are found in equatorial rainforest environments (Clastres 1972; Harrison 1949: Holmberg 1950), no attempt is made to position residential sites with reference to previously occupied residential sites (Binford 1980: 7). Consequently, classic forager residence sites do not accumulate the debris of successive occupations and are relatively ephemeral in their archaeological visibility.

In the case of forager strategies in environments where critical resources, such as water, are confined in occurrence to a few discrete locations the frequency of re-occupation may be significantly higher thereby creating an accumulated palimpsest of successive occupations. Consequently, the archaeological visibility of such sites may be significantly higher (Binford 1980: 7).

Locations are the places where resources are obtained from the environment. As previously indicated, foragers do not generally accumulate resources for storage. Resource procurement tends to be geared to the immediate needs of the residence group. As a result,locations tend to be low bulk procurement sites and, as such, tend to have a low level of archaeological visibility (Binford 1980: 9; see Hayden 1978: 190 - 191). Where residential locations tend to be re-occupied by groups there is clearly a greater opportunity for locations to be utilized more frequently on a year to year basis, thereby accumulating larger quantities of debris.

The extensive use of logistical mobility by collectors has significant implications for the formation of the archaeological record. As task groups move out from the residential site, sometimes incorporating journeys which take weeks to complete, the task group generates a range of sites associated with their activities. Binford (1980: 10 - 12) has discussed and identified the range of sites produced by logistically organized collectors. In addition to the residential site, collectors produce field camps, which serve as temporary residential sites for task groups. Field camps serve as the organizational centre for the task group, being the place 'where a task group sleeps, eats and otherwise maintains itself while away from the residential site.' (Binford 1980: 10).

In addition, collectors produce sites which are associated with the task of gathering information on the disposition of resources. Binford has designated these sites as stations, and they may take the form of ambush points, or hunting stands from which resources are monitored (1980: 12). As previously discussed, collectors characteristically store resources obtained by task groups. When procuring resources task groups obtain quantities above and beyond their immediate needs. Consequently, task groups generate large quantities of resources in the field, and much of this bulk needs to be temporarily stored. The sites associated with this activity of field storage have been designated caches (Binford 1980: 12).

A final category of site generated by collectors is the location (Binford 1980: 10). Locations are the points at which resources are obtained and/or processed. Once again, because collector task groups procure resources above their immediate needs the debris generated at locations can assume large quantities, and consequently may be highly visible archaeologically.

Since collectors generate a wide range of site types the archaeology of collector systems can be highly variable, especially when one considers that the functions of different types of site can be combined in a variety of mixes (Binford 1980: 12, 1982).

In terms of archaeological visibility, the sites generated by collector adaptations tend to be associated with large quantities of material. This is partly a function of the bulk procurement activities of task groups. Importantly, however, the logistical, planned nature of collector mobility promotes the year to year re-occupation of sites. As collectors seek to locate residence sites in order to reduce the procurement costs of spatially predictable bulk resources there is a tendency for specific locations to be re-occupied. Similarly, the exploitation of resources during periods and at locations where they are expected to occur serves to promote the year to year re-occupation of sites by task groups. This high level of site re-occupancy incurs, in Binford's terms, a high level of 'spatial redundancy' (Binford 1980: 9). As Binford has observed,

> 'The greater the redundancy, the greater the potential build-up of archaeological remains, and hence the greater the archaeological visibility.'
>
> (1980: 9).

For serial specialists the archaeological record will, once again, reflect their dependence upon residential mobility as part of their positioning strategy. As with foragers, serial specialists tend to generate two site types, the residence and the location. In contrast with foragers, however, the scheduling of exploitation around specific critical resources at specific locations at any given point of the annual cycle promotes a high level of spatial redundancy. Consequently, serial specialists will generate residences and locations with large quantities of debris from repeated occupations.

Archaeologically, the contrasting patterns of site occupancy and of site types generated by different hunter-gatherer systems carries direct implications for the analysis of lithic assemblages. With an increasing dependence upon logistical mobility the range of site types generated can be expected to increase. In analyzing the lithic assemblages produced by logistically organized hunter-gatherers we might expect to see contrasting assemblage characteristics corresponding to the variations in activities undertaken at residences, field camps and locations. However, as will be discussed in the following sections dealing with the organization of manufacturing and maintenance activities, the analysis of lithic assemblages and the recognition of site types is complicated, methodologically, by the potential effects of tool manufacture and maintenance in anticipation of future use.

In the following sections the organizational dimensions of lithic procurement, manufacture and maintenance will be discussed and the implications for archaeological patterning examined.

2) Lithic procurement

The study of lithic raw material procurement has, in recent years, received considerable archaeological attention. For the most part discussions of the mechanisms by which different communities supply their demands for raw material have concentrated upon the contrasting characteristics of systems where raw material is obtained directly by consumers, and systems where raw materials, or in some contexts, semi-finished or finished products are obtained through the medium of exchange. The distinction between systems of direct and indirect procurement strategies has been seen to have great theoretical value for archaeologists wishing to understand the behavioural implications of different distributional patterns for raw materials, and structural qualities of the archaeological record. As noted by Ericson,

> 'Lithic production systems will vary in structure depending on the procurement strategies used to acquire the material.'
> (1984: 6).

Consequently, a number of archaeologists have sought to develop analytical techniques with which to address archaeological data in order to distinguish between direct and indirect procurement systems. Drawing upon research, primarily developed in geography (Claeson 1968; Haynes 1974; Olsson 1965), into distance-decay effects archaeologists (Findlow and Bolognese 1982; Hodder 1974; Hodder and Orton 1976; Renfrew 1977) have developed formal models of the effects which differing distributional mechanisms have upon spatial patterning in materials. Whilst much of this research has concentrated upon the implications of different modes of exchange direct-access procurement strategies have also received attention.

Common to all the approaches, however, both with regard to direct and indirect procurement strategies, has been the application of the general observation that,

> 'When a commodity is available only at a highly localized source or sources for the material, its distribution in space frequently conforms to a very general pattern. Finds are abundant near the source, and there is a fall-off in frequency or abundance with distance from source.'
>
> (Renfrew 1977: 72).

The rationale for why the frequency of occurrence of a material should decline with distance has been clearly stated by Bettinger (1982) with reference to direct-access procurement systems:

> 'Because the cost of procurement for a specific resource under these circumstances is primarily a function of travel distance to its source, its frequency declines gradually and without obvious changes in rate as distance from the source increases.'
>
> (112).

Findlow and Bolognese (1982: 72) have modelled the distance decay effects of direct-access procurement systems as a linear fall-off, where 'the frequency of visits to the source decreases in a linear fashion with increasing distance', conforming to the model of 'supply-zone usage' as developed by Renfrew, Dixon and Cann (1968: 327). The concept of a 'supply-zone' has been used to account for contexts where a given source is exploited by an immediate regional population and where the same source provides material which moves, through exchange, beyond the immediate regional population. The important issue here, however, is that within the formal modelling of direct-access procurement systems the expectations are that the frequency of occurrence of a raw material will be inversely proportional to increases in distance from source. This arises out of the increasing costs associated with travel and transportation.

The discussion of hunter-gatherer lithic procurement strategies has traditionally viewed lithic procurement as a distinct set of activities undertaken independently of other subsistence behaviour. Conventionally, hunter-gatherers have been regarded as being primarily dependent upon the organization of specific task groups for the procurement of lithic raw materials. Within this view, groups set out from a residential site for the sole and specific task of obtaining the necessary raw materials for their technology. By singling out raw material procurement as a distinct activity set it became possible, if not reasonable, to associate differential costs to raw material sources by relating cost to distance from the residence. As we have seen, such a model conforms to the perspectives surrounding the direct-access mode of raw material procurement.

Gould's recent analysis of raw material use-patterning from his excavations at the Puntutjarpa rockshelter in the Western Desert region of Australia (1978a) provides us with a good example of the 'cost-distance' model applied to archaeological interpretation. Recognizing from within the lithic assemblage a quantity of a highly distinctive chert originating from a distant source Gould attempted to rationalize why the additional costs of obtaining this material had been met when there were alternative, mechanically suitable sources closer to hand. Having discussed the possibility that this 'exotic chert' was mechanically superior to the more local varieties he had to conclude,

> 'Exotic cherts, then were mechanically efficient enough to be acceptable for adze manufacture, but we can reasonably infer that some other consideration led to the ancient aborigines to make the extra efforts needed to obtain them.'
> (1978a:288)

Confronted with archaeological evidence which contradicted his expectations Gould, rather than question the premise for his expectations, dismisses the apparent anomaly through an appeal to the unknown. This is, perhaps, not so unreasonable given the considerable tradition which has grown of relating distance to costs in hunter-gatherer procurement activities. As has been discussed earlier, subsistence decisions are integrally linked to considerations of costs associated with exploitation. Amongst those factors which determine exploitational costs distance is clearly one of the most important.

Recently, however, the work of Binford (1979) has provided an alternative perspective of the ways in which hunter-gatherers maintain their supplies of lithic raw materials. Binford's perspective of the lithic procurement activities of hunter-gatherers stemmed from his extensive fieldwork amongst the Nunamiut (Binford 1978a). The Nunamiut occupy an environment where they are confronted with the problems of extreme seasonal variability in their access to critical resources, and provide a classic example of collector strategies in operation. Nunamiut subsistence is centred around two environmental resource events, the spring and autumnal migrations of caribou. During these two temporally restricted periods, totalling approximately thirty days in all, the caribou are aggregated and move along relatively predictable migration routes. The Nunamiut employ an intercept strategy whereby they monitor the movement of caribou and select the most favourable time and place from which to exploit the resource. During the thirty days of the migrations the Nunamiut obtain over seventy percent of their total annual food requirement (Binford 1979: 256). Consequently, the Nunamiut exhibit a heavy dependence upon stored foods for much of the year. Confronted with the problems of integrating spatially and temporally incongruous resources, the dependence upon storage provides a solution to the temporal difficulties, but places further demands upon the spatial integration of resources through the use of logistical mobility. As a result, the Nunamiut represent an extreme example of a collector system, with a heavy reliance upon storage and logistical strategies. The benefits of learning from such an extreme situation have been clearly stated:

> 'An "extreme" case often facilitates comparison with other "extreme" conditions, and promotes appreciation of variability "between the extremes" better than does an understanding of a "modal" case.'
>
> (Binford 1979: 255).

During the course of his work amongst the Nunamiut Binford was made aware of the relationship which existed between the primary subsistence activities of the group and the ways in which lithic raw materials were obtained. The Nunamiut's subsistence strategy involved frequent logistical moves to selected areas in order to obtain specific resources. Outside of the spring and fall migrations, task groups were continuously engaged in journeys to transport cached food supplies, or to obtain fresh resources from either hunting or fishing, or setting traps to obtain fur bearing species. During the course of these logistical moves Binford noted that raw materials were obtained and either cached for future use, or kept and transported back to the residence site with the returning task group. Crucially, it was noted that,

> 'Very rarely, and then only when things have gone wrong, does one go out into the environment for the express and exclusive purpose of obtaining raw materials for tools.'
>
> (Binford 1979: 259).

Raw materials were being obtained incidental to the primary subsistence strategy, or in Binford's terms, raw material procurement was 'embedded in basic subsistence schedules.' (1979: 259). When, and only when, the primary purpose of the logistical group's activities resulted in a relatively low return, and they had the free capacity to transport material, did they transport fresh raw materials back to the residence site. The implications are that, regardless of the distance to the residential site, raw materials were obtained in lieu of other resources at no additional cost. Therefore, embedded lithic procurement strategies integrate raw materials during the course of activities within the broader sphere of subsistence schedules. Task groups do not set out specifically to obtain lithic raw materials. Therefore, considerations of distances from residential sites to raw material sources do not constrain lithic procurement. The costs of travel are associated with primary subsistence schedules, and, consequently, any lithic materials obtained cannot be directly equated with distance-cost considerations.

The recognition of the characteristics of embedded procurement presents a number of most significant implications for lithic analysts and the interpretation of raw material patterning in archaeological assemblages. When dealing with assemblages produced within embedded strategies of lithic procurement the presence of a variety of raw materials from spatially discrete sources can be understood, in part, as reflecting the scale of subsistence activities across a landscape. Put another way, the presence of a variety of raw materials in an assemblage,

> 'may simply be a fair measure of the mobility scale of the adaptation appearing as a consequence of the normal functioning of the system, with no extra effort expended in their procurement.'
>
> (Binford 1979: 261).

Given the potential to identify the mobility scale of hunter-gatherer subsistence behaviour from the range of raw materials present in an assemblage lithic analysts could confidently discuss the mobility scale of prehistoric adaptations. Such a potential would offer important methodological strength to our understanding of prehistoric hunter-gatherer adaptations as a whole.

However, there are other important considerations which need to be accounted for before such an approach could be confidently adopted. First, within the characteristics of an embedded system of procurement we noted that the input and transportation of raw materials was governed, in part, by the facility for transportation in lieu of other resources. From this, we can see that the degree to which raw material inputs would reflect the scale of subsistence mobility would be largely determined by the consistency and frequency of occurrence of spare transport capacity within the annual subsistence activity schedule. As noted by Torrence (1983), embedded procurement serves to avoid wastage of time in sending task groups to obtain raw materials, where the time is best spent in food resource procurement (12). Such a strategy makes sense in collector adaptations where the efficient scheduling of time avoids conflicts between activities, and helps to minimize the risks of failure. In undertaking different resource procurement activities in different locations the degree and regularity of success in the primary subsistence objectives might be highly variable. Consequently, the input of raw materials from various exploitational locations might exhibit considerable variability. As a result, the proportions of different raw materials within an assemblage may be biassed in favour of sources in areas associated with subsistence activities which, during the course of task group mobility, incur a higher rate of transport capacity for secondary inputs, such as raw material procurement. We might, for example, expect that during the periods when resources are relatively dispersed, or when task groups are, as a primary activity, simply monitoring the distribution of resources, there may be a higher capacity for secondary inputs than is the case with periods when predictable resource aggregations are being exploited.

A second, and most crucial consideration regarding the interpretation of raw material procurement strategies concerns the general appropriateness and applicability of embedded strategies. As we have seen, embedded procurement systems avoid conflicts in time allocation when the efficient scheduling of subsistence activities is desirable, as is the case with collector strategies. Forager strategies differ from collector strategies in that, in a neo-Darwinian sense, there is less selective pressure for efficiency in the scheduling of specific subsistence activities. To what extent, therefore, can we expect lithic procurement to be embedded, so as to avoid conflicts with other activities, in forager systems? In the light of this legitimate question, the following accounts of lithic procurement activities amongst forager groups are potentially informative. Gould, discussing lithic procurement amongst Western Desert aborigines, has noted,

> 'I found it impossible to make accurate calculations of the time spent by individuals in obtaining raw materials at quarries, mainly because this behaviour was combined with other activities such as hunting and visits to sacred sites.'
>
> (1977: 164).

Similarly, Yellen (1977) has made the following observation concerning the procurement of raw materials by the Dobe !Kung:

> 'activities taking place away from the campsite are limited almost entirely to hunting, gathering, and collection of raw materials for manufacturing goods. This latter task is generally incidental to food collecting.'
>
> (73).

In both of these accounts we gain the impression that lithic raw material procurement amongst forager groups may be undertaken incidental to other primary activities, thereby conforming to the general principles of embedded procurement. As we have discussed, in general terms forager strategies procure resources within a foraging radius around the residential site. The foraging radius is spatially constrained by the distance which can be covered during the course of one day and which enables resources to be both procured and returned to the residential site. We might, therefore, expect that the input of lithic raw materials might reflect the availability of sources within the foraging radius. Comparisons of lithic assemblages produced by collector and forager systems might, therefore, be expected to show a marked contrast in so far that collectors may procure materials from very distant sources, whilst foragers will primarily obtain raw materials from sources near to the residence. For lithic analysts, therefore, the analysis of raw material patterning in archaeological assemblages should provide an important analytical tool in discussing the mobility scale of a prehistoric group during the course of subsistence activities. We must, however, consider two additional points which may complicate such an interpretative procedure.

We have previously noted that the characterization of forager and collector mobility strategies as being differentiated in their dependence upon residential versus logistical mobility is, whilst appropriate and useful, a generalization. Forager strategies do, periodically, encompass logistical mobility with task groups moving for extended periods away from residential sites. By the same token, collector systems may occasionally employ task groups for the specific purpose of collecting raw materials.

Gould (1978b) provides us with an account of the influence which distance plays in the organization of task groups designed specifically to obtain raw materials.

> 'These visits were often planned ahead of time, since quarries seldom occur in close proximity to waterholes where aborigines might otherwise camp in the normal course of their hunting and gathering. Special efforts were made by aborigines to visit quarry locations .... White chert was always collected in this manner, from localities known to lie within a day's walk of a habitation base camp.'

(830 - my emphasis).

In the above example we gain a clear impression of visits to quarries for the specific purpose of obtaining raw materials. Importantly, however, this is done within the foraging radius.

Whilst the general pattern of mobility should predominantly influence the raw material input to assemblages, there may be inputs from strategies of procurement which differ from the overall pattern. In the case of forager systems the use of task groups might influence, under certain circumstances, the raw material input to a considerable extent. Whilst the distribution of environmental resources in generalized environments might be spatially undifferentiated, no such guarantee applies to the distribution of mechanically suitable lithic sources. In circumstances where the distribution of lithic sources is uneven, and does not necessarily coincide with the foraging radius, a forager system might utilize task groups specifically to obtain raw materials. This situation may be more acute in foraging systems where residential mobility is constrained, for all or parts of the year, by the localized availability of a critical resource, such as is the case in certain arid environments. We might, as a result, see forager systems employing task groups, on a regular basis, to obtain lithic raw materials which occur outside of the foraging radius. This would clearly complicate the relationship between assemblage raw material patterning and interpretations of mobility. To this end, it is important that interpretations of the raw material content of a given assemblage should incorporate some assessment of, what Ericson (1984) has termed, 'the regional lithic resource base' (5).

Recently, a debate has developed concerning the significance and interpretation of raw material patterning at sites in the Australian desert (Binford and Stone 1985; Gould 1985; Gould and Saggers 1985) which serves to illustrate some of the points made above. At the

Puntutjarpa site high quality flaking materials represented in the assemblage were derived from sources in the immediate vicinity of the site. Given a forager pattern of mobility the preponderance of such raw materials in the Puntutjarpa assemblage presents no particular surprise. However, at the James Range East site the presence of high quality flaking material in the assemblage from sources beyond the immediate foraging radius has stimulated discussions as to the mode of procurement. Interestingly, it is apparent that within the foraging radius of the James Range East site no such high quality sources exist. It is possible that, as discussed above, the absence of suitable raw materials within the foraging radius may have led the occupants of the James Range East site to organize raw material procurement through task groups moving beyond the foraging radius.

For energy-stressed forager groups the expenditure of additional inputs of time in the collection of raw materials through task groups might not represent a detrimental strategy. Given that the segregation of subsistence and technological activities amongst foragers conveys less benefits than amongst time-stressed collectors we might expect, on occasion, foragers to procure raw materials through task groups specifically organized for the task. Amongst time-stressed collectors, however, such a strategy of lithic procurement would run the risks of conflicting time allocations between subsistence and technological activities. It is possible, however, to conceive of such strategies operating during periods when subsistence activities are at a minimum.

Given that both collectors and foragers may employ embedded and non-embedded lithic procurement strategies it is important that lithic analysts develop approaches designed to distinguish between procurement mechanisms. Furthermore, the traditional distinction between direct-access and indirect-access needs to be expanded to distinguish embedded and non-embedded direct-access procurement mechanisms. Only through the development of such discriminatory approaches will the lithic analyst be in a position to examine raw material patterning as an effective index of the mobility scale of prehistoric hunter-gatherer subsistence activities.

a) Measures of procurement

As an initial step towards the development of discriminatory measures of procurement mechanisms we can consider the implications of differing mechanisms for the spatial distribution and quantitative representation of raw materials in archaeological lithic assemblages.

i) Direct-access: non-embedded

As previously discussed, the model proposed by Findlow and Bolognese (1982), and Bettinger (1982) for direct-access task group procurement is depicted as a steady inverse linear relationship between increasing distance from source and the proportion of raw material represented at a site. This is illustrated in figure 5a.

ii) Direct-access: embedded

In our discussion of embedded procurement systems we identified that raw materials were obtained incidental to primary subsistence activities. Since the costs relating to distance are associated with the primary subsistence schedule, the costs of the procurement of raw materials cannot be directly related to distance. Under these circumstances, therefore, the proportions of raw materials within an assemblage need not show any particular relationship, inverse or otherwise, with increased distance from source (fig. 5b). As such, systems of embedded procurement may produce raw material distributions which depart from traditional expectations of decreasing frequency with increased distance from source but, as

Renfrew (1977: 72) has recognized, departures from our expectations 'are likely to be of interest and significance.'.

Having examined the predicted effects of task group organized and embedded procurement systems upon the spatial distribution of raw materials we can see that it should be possible to differentiate between the two mechanisms. The constraining influence of distance in task group organized procurement can provide the basis for alternative approaches to the study of lithic procurement strategies. Before we examine these alternatives, however, it is important that we consider the implications of indirect procurement strategies for the distributional patterning of materials. As will be shown, the distinction between task group organized procurement and certain indirect mechanisms may present further analytical problems.

b) Indirect access modes of procurement

Sahlins (1972) has discussed the relationship between commodity value and exchange systems in a variety of contexts. From the analysis of gift exchange systems in Queensland (Sharp 1952) Sahlins (281) identified that the exchange values of spears, manufactured at a source close to Yir-Yoront, relative to stone axes, manufactured at a source some distance south of Yir-Yoront, varied in relation to distance from the points of manufacture. Sahlins observed that,

> 'At Yir-Yoront, near the northern source of spears, 12 of them must be given for a single axe; about 150 miles south, that much closer to the source of axes, the rate falls to one to one; in the extreme south the terms (apparently) become one spear for "several" axes.'
>
> (282).

Similarly, in the middlemen trading networks of the Siassi Islanders, Sahlins (op. cit.) noted that,

> 'Exchange values not only varied locally with supply/demand - judging again by the difference in terms according to distance from origin - but monopolistic sharp practice may have afforded discriminatory gains.'
>
> (285).

Despite the operation of very different organizational forms in the structure of exchange networks the relative costs of acquiring commodities can be related to the interplay of variations in supply and demand. As stated by Sahlins,

> 'in each case a certain play of supply/demand is detectable in the rates of exchange.'
>
> (1972: 280).

In the cases examined by Sahlins a constraining role for increasing distance from commodity source can be identified with respect to supply. Although the intervention of specific mechanisms, such as the individualistic capitalization of middlemen traders upon localized variations in the perception of commodity values, may introduce irregularities in the costs of a particular commodity the general pattern is one of increasing cost related to increased distance from source. We can, therefore, seek to model the cost-distance implications of differing indirect mechanisms of supply in an initial attempt to provide a basis for distinguishing between different mechanisms.

In his examination of the implications of differing modes of exchange for the spatial distribution of materials Renfrew (1977) discussed a variety of models. The present discussion will focus attention upon just two of these models.

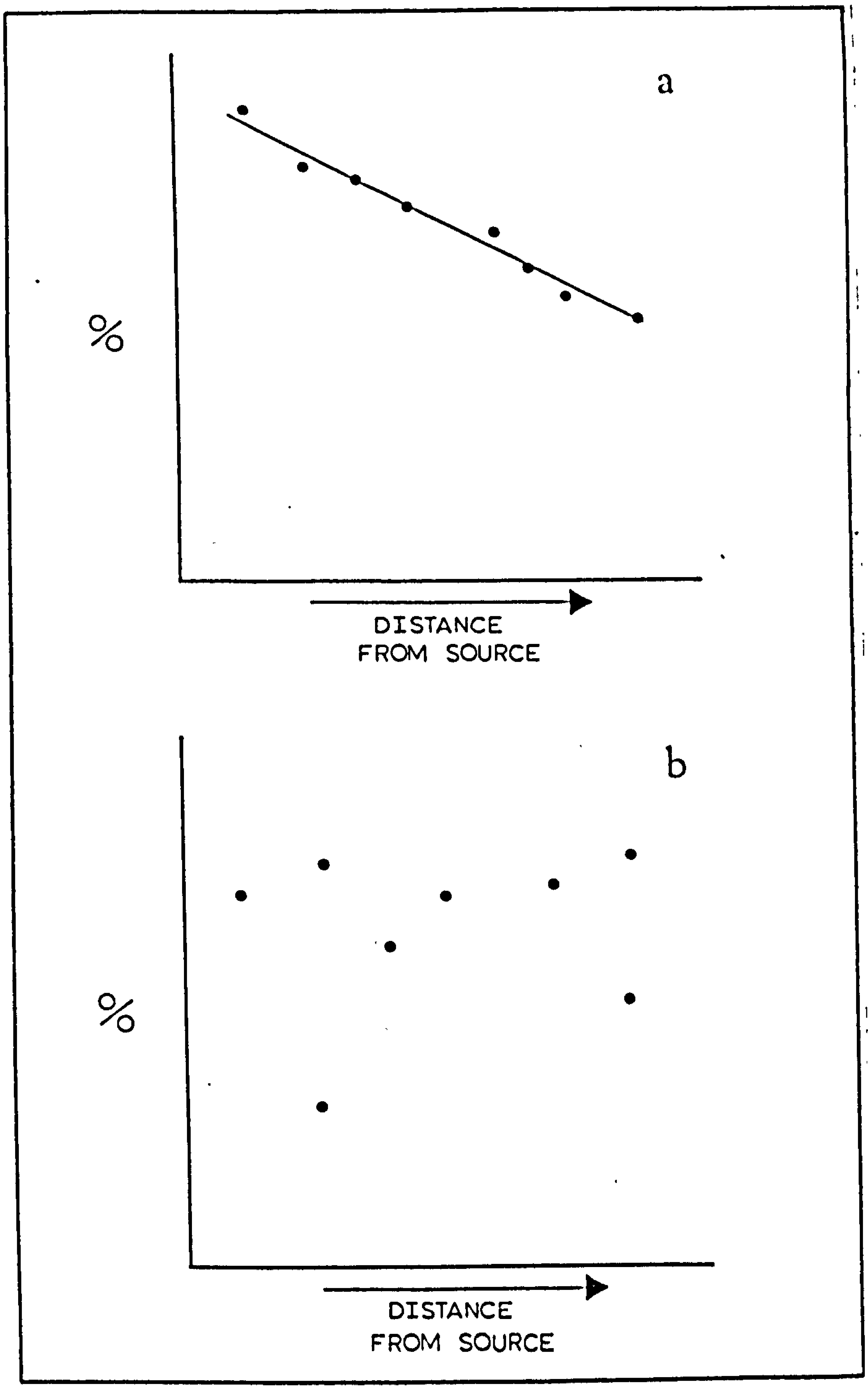

a
%
DISTANCE FROM SOURCE
b
%
DISTANCE FROM SOURCE

fig. 5

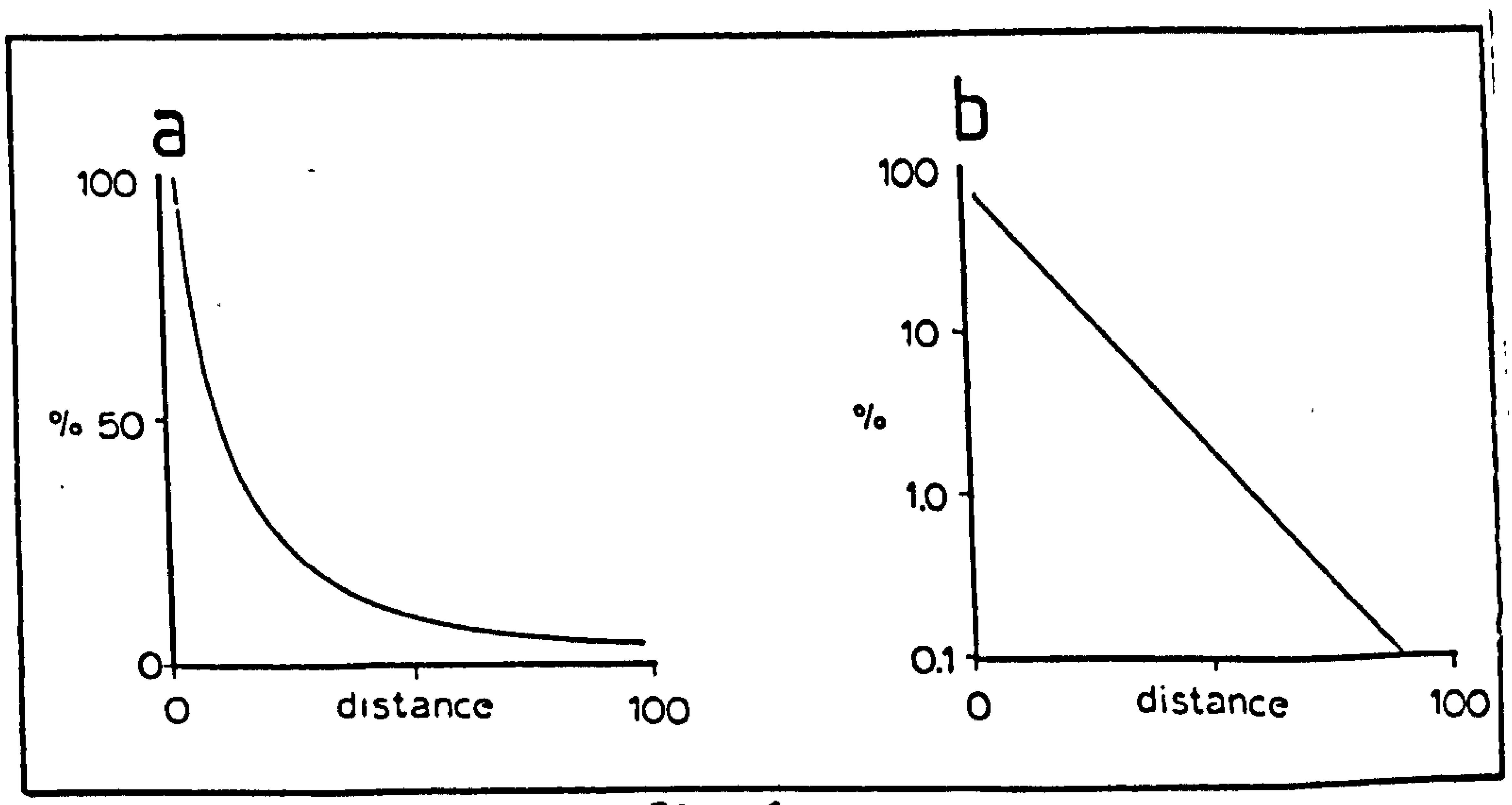

a
100
% 50
0
0
distance
100
b
100
10
%
1.0
0.1
0
distance
100

fig. 6

i) Exponential distance decay

Whilst investigating the distributional pattern of obsidian in the Near East (Renfrew et al. 1968) attention was drawn to the exponential character of the fall-off in obsidian with increasing distance from source. It was demonstrated that by plotting the percentage of obsidian in different assemblages on a logarithmic scale, against distance from source on a linear scale, an approximately linear fall-off was achieved. The theoretical model for the distributional characteristics of exponential distance decay is illustrated in figure 6, along with the log-linear transformation.

Subsequently, the possible mechanism responsible was outlined (Renfrew 1972: 446). Renfrew envisaged a situation where equally spaced villages, linearly distributed, each received a commodity from its neighbour nearest to the source. Some of the commodity is used and enters the archaeological record. Each village passes on a given proportion of the quantity initially received. The exponential fall-off is thereby generated, in a series of exchanges. As Renfrew (1977: 78) has noted, it is possible to replace the assumption of a linear arrangement of equally spaced villages with that of a uniform population distribution. The important element governing exponential fall-off 'is that the reduction is proportional to the number or quantity at the point in question.' (Renfrew 1977: 79).

ii) Supply-zone effect

An alternative situation has been recognized (Hodder 1974; Renfrew 1975, 1977; Renfrew et al. 1968) where, in the immediate vicinity of a source, materials move through individual transactions. As previously indicated, we can conceive of a situation where individuals, or task groups, move directly to the source to obtain a commodity.

The resulting linear fall-off can, however, be generated under circumstances where 'the producer is travelling with his goods direct to the purchaser.' (Renfrew 1977: 84). Renfrew has designated this type of fall-off as 'supply-zone' behaviour (1977: 84). The important point here is that two mechanisms of procurement, one being direct and the other indirect, can produce the same fall-off characteristics.

Furthermore, if the commodity then moves beyond the sphere of supply-zone behaviour, through an indirect procurement mechanism, we may find an overall fall-off which reflects two distinct mechanisms. Renfrew (1977: 78) has illustrated this situation, where a supply-zone mechanism produces a linear fall-off close to the source, and where the commodity then passes into a 'down-the-line exchange' system resulting in an exponential fall-off (fig. 7).

In a discussion of obsidian procurement within the Valley of Mexico Hirth (1984: 140) has argued that the distribution pattern conforms to the expectations of the supply-zone model. Throughout the Formative period, according to Hirth, the supply was maintained by direct procurement (see also Spence 1984). Interestingly, Hirth goes on to argue that as the distance from source increases a point is reached where 'the fall-off rates become steeper.' (140), and he compares this directly with the model of combined supply-zone procurement and down-the-line exchange outlined by Renfrew. The recognition of combined, spatially discrete mechanisms in the fall-off of a material from a known source is potentially of intrinsic interest to archaeologists in that such a situation could provide an important basis for examining spatial discontinuities in socio-economic interaction in the prehistoric past.

Having briefly examined the spatial implications of differing modes of raw material procurement it is apparent that embedded systems are differentiated from task group organized and indirect mechanisms in that distance does not act as a constraint. Task group and indirect procurement systems of procurement may, however, be difficult to separate and distinguish on the basis of fall-off patterns. In particular, the effects of task group organized and supply-zone indirect mechanisms may be virtually indistinguishable simply in terms of fall-off patterning.

The theoretical and methodological importance of embedded systems of procurement to the discussion of hunter-gatherer mobility scales demands that lithic analysts should seek a variety of analytical approaches in order to justify its application to prehistoric data. As previously mentioned, the contrast in the constraining effects of distance-cost considerations between embedded, non-embedded and indirect mechanisms of procurement can provide the basis for alternative analytical approaches. Under circumstances where the mode of procurement incurs increasing costs related to increasing distance from source we might expect to find marked variations in the degree to which groups or individuals attempted to maximize the utility of a raw material. In the following section, the organization of lithic manufacture and maintenance will be discussed, and attention will be drawn to the importance of differing procurement strategies for the degree of time and energy invested in producing and maintaining a technology.

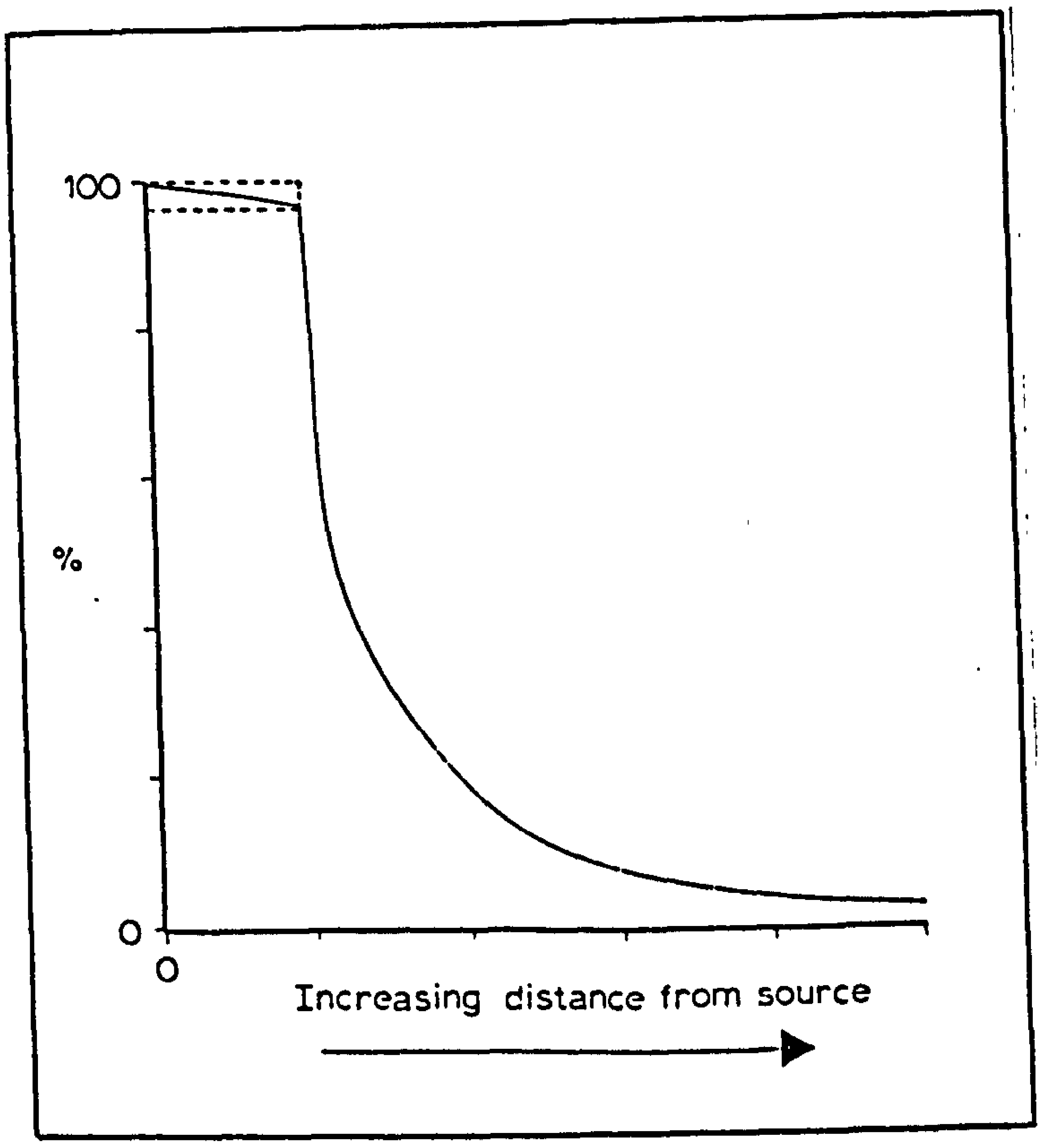

100
%
0
0
Increasing distance from source

fig.7

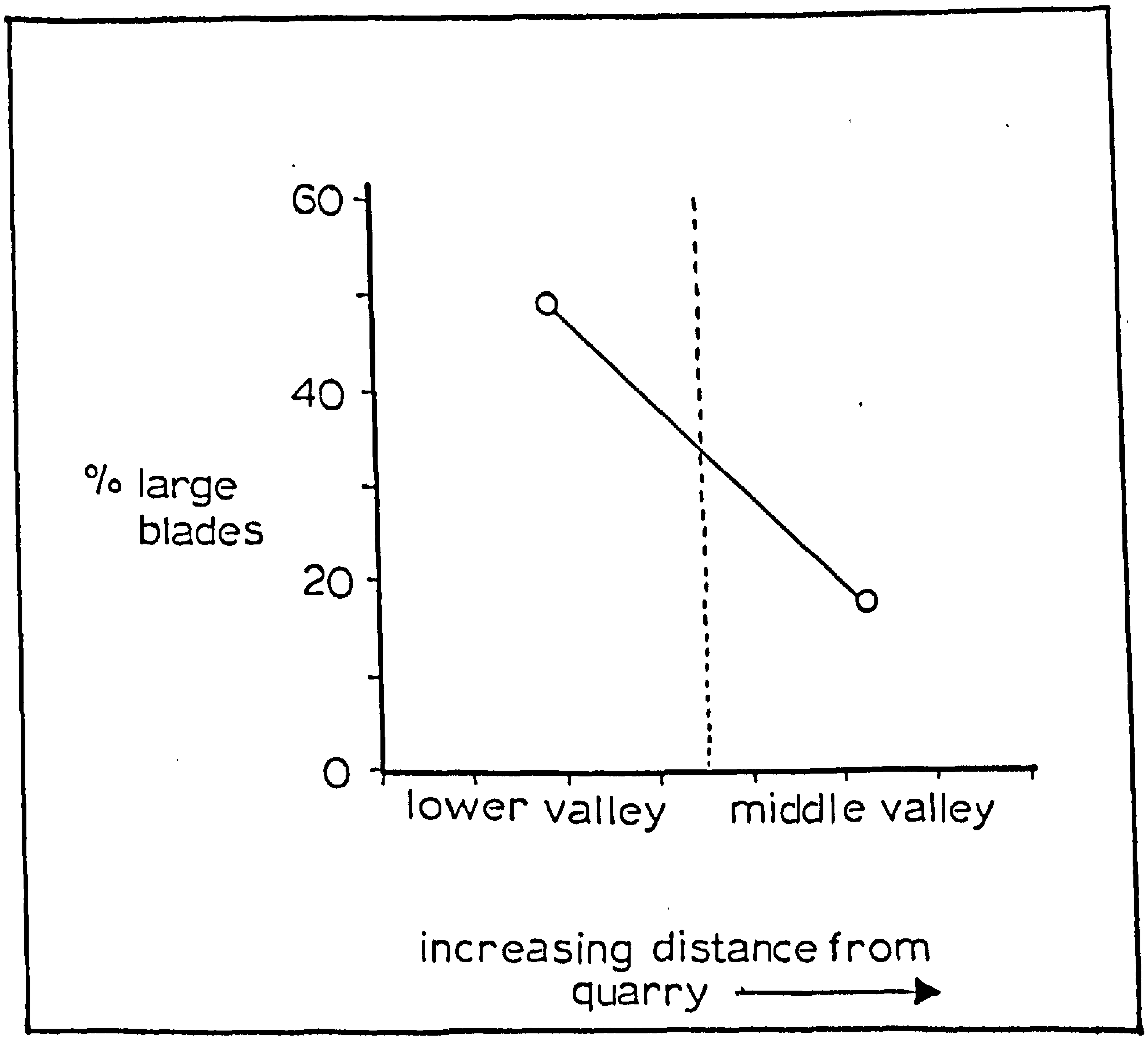

60
40
% large
blades
20
0
lower valley
middle valley
increasing distance from
quarry

fig.8

3)Manufacture and maintenance

We have seen that for hunter-gatherers living under conditions where the efficient scheduling of exploitational activities is advantageous the procurement of raw materials may be embedded within the subsistence schedule so as to avoid conflicts in time allocation. So too, recent research has demonstrated that the organization of tool manufacture and repair can be effectively scheduled in order to avoid a conflict between the time required for technological activity and the primary subsistence schedule (Binford 1978b; Torrence 1983; Zvelebil 1984).

Collector strategies, as previously discussed, frequently involve the exploitation of mobile resources which exhibit a high degree of spatial and temporal incongruency. Under these conditions the annual subsistence schedule incorporates periods of intensive exploitational activity which coincide with improved conditions for the efficient exploitation of particular species. The need to capitalize upon the temporary occurrence of aggregated resources and provide sufficient resources for storage places a heavy technological demand upon such systems. For example, the exploitation of caribou migrations, where a substantial proportion of the total annual food requirement may be obtained, will place a heavy demand upon the production of equipment required during this intense exploitational period.

In contrast, forager systems maintain a steady, day to day input of food resources. The exploitation of a range of mobile and non-mobile resources that are spatially and temporally undifferentiated ensures that demands upon technology are evenly distributed throughout the year. The differing exploitational demands of collector and forager strategies serve to differentiate the two strategies in terms of the distribution of technological activity throughout the annual cycle (see Zvelebil 1984: fig. 1). Given the high risk associated with the exploitation of mobile resources, especially in the absence of non-mobile, low-risk resources as an alternative, hunter-gatherers in higher latitude environments need to schedule their technological activity in order that it does not conflict with the time required for exploitation. As noted by Torrence,

> 'In the case of hunting caribou, the major source of food for the Nunamiut, the time available for capture of the resource is limited due to the high mobility of the animal and to its seasonal occurrence in the area. Production of tools used to kill caribou must therefore be planned so as not to detract from the small amount of "pursuit time". Consequently, tools are manufactured well in advance of sighting the game.'
>
> (Torrence 1983: 12).

a) Curation

Binford (1972: 265, 1973, 1976) has discussed the manufacture of tools in anticipation of future use, and termed this strategy 'curation'. Curative behaviour applies not only to the anticipatory manufacture of tools, but also the maintenance and repair of technology. Just as the manufacture of tools, under conditions of time-stress, can be scheduled to avoid conflicts in time allocation then, so too, the scheduling of maintenance and repair activities can serve the same purpose (c.f. Torrence 1983: 12).

The concept of curation carries far reaching implications for the study of lithic assemblages from archaeological contexts. Binford (1973, 1976) has discussed at length the implications of curative behaviour for the formation of the archaeological record. Traditionally, archaeologists have regarded the archaeological record as being a direct reflection of 'the organization of the on-going activity structure of the group.' (Binford 1973: 242). Curative behaviour, however, serves to displace the contexts of tool manufacture, use, maintenance and discard. We are invited, in Binford's words, to envisage a situation where,

> 'The more that tools are curated, transported, and preserved for future use, the less the correspondence there will be between the behavioural context of their use and their associated occurrence in the archaeological record.'
>
> (1973: 242).

One of the consequences of curative behaviour, therefore, is that as curation increases the relationship between the content of assemblages, in terms of discarded tools, and their contexts of manufacture and use becomes less direct, and tool assemblages at functionally differentiated sites become increasingly undifferentiated (Binford 1973: 250, 1976: 347). Consequently, we might expect that compared to situations where tools are manufactured expediently (Binford and Binford 1969: 81), when and where they are needed, inter-assemblage variability should be relatively low. Expedient strategies, on the other hand, will produce an archaeological record with a potentially high level of inter-assemblage variability which will,

> 'vary directly with the seasonal and situational differentiation in the locus of task performance.'
>
> (Binford 1976: 346).

At this point it is important to acknowledge that, as is the case with the contrasting characteristics of collector and forager strategies, the characterization of any specific hunter-gatherer technology as curated or expedient will be a matter of degree, and they should not be regarded as mutually exclusive. Within any hunter-gatherer technology we can expect to find items which are subject to high levels of maintenance, repair or recycling, and others which are expediently manufactured, used, and discarded. Binford (1979) has distinguished between various categories of equipment amongst the Nunamiut. He found that three types of equipment could be identified: personal gear, site furniture, and situational gear. Importantly, Binford noted that,

> 'Both personal gear and site furniture were viewed as anticipatory in character, while situational gear was responsive in character.'
> (Binford 1979: 261)

Situational gear is manufactured for the purposes of a specific task at a specific location, and is not subject to prolonged maintenance or transportation. The expedient nature of situational gear ensures that the contexts of discard will reflect, directly, the contexts in which it is produced and used. The recycling of broken bifacial projectile points (an item of personal gear) to produce knives for butchering at kill sites (situational gear) amongst certain North American plains hunter-gatherers (Frison 1970, 1974; Wheat 1976) represents one example of the responsive nature of situational gear.

By the same token, it is clear that amongst forager adaptations some items of traditional technology are subject to prolonged maintenance and transportation. In the Western Desert of Australia, for example, some items are subject to repeated resharpening and maintenance thereby extending an artifact's use-life (Gould 1980: 130; Hayden 1977). Similar observations have been made by Yellen (1977: 76) concerning the organization of technological activity amongst the Dobe !Kung.

However, as we have seen, the overall level of curation in a technology might be regarded as an indicator of the degree of time-stress operating upon subsistence scheduling. From this, we might expect that adaptations to conditions where there are benefits to be had through the efficient scheduling of subsistence and technological activities will exhibit a high level of curatorial behaviour.

As Binford (1976) has noted,

> 'a logistics strategy in which foods are moved to consumers may be expected to be correlated with increases in curation and maintenance of tools, since both are organizational responses to conditions in which increasing efficiency would pay off.'
>
> (345).

The analysis of lithic assemblages with the aim of identifying and assessing the level of curation could, therefore, provide a valuable means of discussing the degree of time-stress operating upon the subsistence schedule. Binford (1976: 341 - 344) has outlined a series of expectations concerning the content of assemblages as a means of distinguishing between curated and expediently organized technologies.

However, as a factor influencing the level of inter-assemblage variability Hayden (1975) has questioned the value and justification of the concept of curation. Hayden's criticisms of the concept stemmed from doubts concerning the validity of Binford's experiences amongst the Nunamiut. The Nunamiut employ a 'westernized' technology, and Hayden argued that attitudes to the care and maintenance of western items of technology, such as steel axes, are markedly different from those which would pertain in the use of a traditional, stone-based technology. Stone, he argued, was and is a common commodity, and that,

> 'as a rule, material (stone) was easily obtainable and functionally adequate tools were easily manufactured. Consequently they were of much less value in hunter-gatherer societies than functionally equivalent metal items.'
>
> (49).

There is considerable evidence that metal items introduced into stone-based technologies can achieve, or be invested with a high value. This value has been partially associated with the relative functional efficiency of metal tools (Townsend 1969), and also as a symbol of social ties with more westernized groups. (Gould 1980: 18 - 20 gives an account of the interaction between 'desert people' and 'mission people'.) Sometimes the increased availability of western items has had drastic consequences for the traditional social order of communities (Sharp 1952).

However, Hayden's argument does not detract from the importance of curation as an adaptive technological response to conditions where the efficient scheduling of technological activity can avoid conflicts in time allocation with subsistence activities. Rather, the argument put forward by Hayden serves to indicate the potential effects upon levels of curation of situations where the supply of a commodity is restricted and incurs costs. Since access to metal items is restricted amongst Western Desert groups to mechanisms where costs are incurred (journeys to trading posts or other, more westernized groups) it is not surprising that metal items are highly curated.

The important issue here is that rates of curation, in addition to being adaptive responses to time-scheduling demands, can also be responsive to conditions where costs are incurred in procuring a commodity. This dual role for curative behaviour demands careful consideration when we seek to interpret archaeological assemblages. On the one hand, curation may be part and parcel of technological responses to time-scheduling demands. On the other, the rate of curation may be responsive to raw material procurement mechanisms where costs are incurred. Given the potential value and importance of curation as an analytical tool for examining time-stress in subsistence schedules there is an even greater need to identify those effects which may be related to the procurement mechanism. For example, where the procurement mechanisms incur costs related to distance from source we might expect to find the level of curation increasing at sites which are more distant from sources. In embedded procurement systems, where cost-distance considerations do not apply, the level of curation might be taken directly as a measure of the degree of time-stress operating in the subsistence schedule.

The need to distinguish between cost related and embedded procurement systems places a further demand upon the analysis and interpretation of lithic assemblages. There is a need to examine assemblages in order to identify levels of curation, and to relate these levels to distances from raw material sources. Where we identify no significant relationship, then we can proceed to infer an embedded system of procurement and examine curation levels as a measure of time-stress in the subsistence schedule. From this we can see that lithic analysts must be concerned with the development of methodologies for measuring the level of curation in assemblages. Such methodologies as are developed must be amenable to quantification across a regional landscape in order that the differential effects of distance from raw material sources can be examined. In the following section the directions which such analyses might take are examined and discussed.

b) Measures of curation

In the preceding discussion the potential role of increased levels of curation as a response to the increased costs of raw material procurement was briefly examined. In this section the methodological basis for examining rates of curation in the manufacture, repair and maintenance of lithic technology will be examined in detail. In view of the analytical importance of curative behaviour as a key to understanding the broader sphere of hunter-gatherer subsistence and settlement organization, and as a factor influencing the structuring of inter-assemblage variability the ability of lithic analysts to distinguish between curation as a response to raw material procurement costs and as an adaptive response to scheduling demands merits detailed examination.

We have identified the relationship between procurement systems where the costs of obtaining raw material increase as a function of distance from sources and the expected fall-off patterns in the frequency of a raw material. In cost-distance related procurement systems we can expect that the value of a commodity will rise with increasing distance from the commodity source. Developing upon this observation, the role of curative behaviour might be expected, under these conditions, to increase as the costs of raw material procurement increase. As materials become more expensive to obtain, whether through direct task group organization or through indirect procurement mechanisms, the level of economy in the manufacture, maintenance or repair of items can be expected to increase in order to extend the utility of the raw material. Consequently, we need to devise measures by which we can quantify the degree of economization in the use of a raw material. Once we have developed the means by which such measures may be made it should be possible to test the proposition that curation will increase with increased distance from source as a function of the costs of procurement.

As an initial step towards identifying measures which may serve as indices of economization in the use of raw materials we can consider the various stages in the production and maintenance of a lithic technology. Since lithic technologies are subtractive, that is to say each stage in the production of lithic tools involves the reduction of a mass through the removal of material, the level of economization in a lithic industry may be reflected at the various reductive stages. Although lithic technologies vary in the goals and techniques of production, the manufacture of chipped stone tools is, in part, governed by the mechanics of conchoidal fracture (Crabtree 1972; Frank and Lawn 1967; Goodman 1944; Speth, 1972). Given the techniques for applying and controlling force in order to reduce a microcrystalline or cryptocrystalline mass the production of usable stone tools involves 'certain basic and unavoidable reductive steps.' (Collins 1975: 16).

In discussing the steps, or stages associated with lithic reduction Collins (1975) identified five general reductive stages in his generalized model (17 - 23). Those stages are 1) acquisition of raw material, 2) core preparation and initial reduction, 3) optional primary trimming, 4) optional secondary trimming and shaping, and 5) optional maintenance/modification.

i) Raw material acquisition

We have previously discussed the various mechanisms through which raw materials may be obtained. The sources of suitable materials exhibiting the desired characteristics of conchoidal fracture can be extremely diverse, both in their nature and in the procedures required to extract material. Sedimentary, igneous or metamorphic materials may all exhibit the necessary mechanical properties. Their occurrence may be within the parent, geological material or in a secondary context such as river gravels, glacial moraines or boulder clays. The extraction of raw materials may, as a result, demand various degrees of energy expenditure. The quarrying of raw materials can involve the extraction of masses which occur at or near the surface, through to the large-scale removal of surrounding geological parent material in order to reach suitable deposits. On the other hand, raw materials may be extracted with relative ease from secondary contexts where material may occur on the surface, or combined in a relatively soft matrix.

Once a raw material mass has been extracted the process of reduction may begin. It may be necessary to evaluate the relative mechanical properties of a material prior to transportation, in which case initial reduction may take place at the source. In other contexts the initial reduction may take place at another location.

ii) Core preparation and initial reduction

As stated by Collins (1975: 20 - 21) the form of initial reduction and core preparation will be dependent upon 'size, quality, shape of pieces and nature of surfaces, abundance and condition.'. At this stage the reduction of the mass may be geared to the immediate production of pieces suitable for use as tools, or for the purposes of further reduction. In many instances this initial reductive step will involve the removal of some or, possibly, all of the external surface of the mass. The mechanical properties of a raw material may be modified at points where the material was in contact with the parent geologic body, or subject to agencies of weathering (i.e. water, freeze-thawing). The removal of such transitional, external material may be a prerequisite for subsequent controlled reduction. As recognized by Collins,

> 'With more sophisticated objectives, the core must be prepared with careful attention to the form of the core face, core platform, and the angle between these surfaces ....'
>
> (1975: 21).

The controlled reduction of a core in order to produce regularly shaped flakes and/or blades for tool manufacture demands that considerable care be given to the morphology of the core prior to continued reduction. Whilst the details of the steps in core preparation will vary considerably depending upon the characteristics of the raw material mass, the desired end product etc., it is useful at this point to consider some of the methods by which a knapper can ensure success in the controlled reduction of a core.

Crabtree (1968: 460 - 467) has outlined the various preparatory steps involved in the production of cores for manufacturing prismatic blades. In many respects we can regard the controlled manufacture of prismatic blades as an extreme example of a technology demanding considerable core preparation and care on the part of a knapper. The various techniques employed in the account of blade production given by Crabtree, provide us with clear indications of the various demands of controlled lithic reduction and the ways in which those techniques serve to ensure success in reduction.

Initially, the preparation of a core for blade production demands the establishment of a platform to which force may be applied in order to remove the blades. As previously mentioned, certain raw materials may occur with suitable natural surfaces to act as platforms (Crabtree 1972: 84), but in other situations it may be necessary to split a raw material mass to provide a suitable platform surface (Crabtree 1968: 460). One important consideration in the establishment of a platform is the angle between the platform surface and the face of the core from which subsequent removals will be made. Depending upon the type of core desired the angle between the platform and core face can vary between a right angle and an oblique angle in excess of 45^{o} (Bordes and Crabtree 1969: 4; Speth 1975: 205 - 206). Within these parameters the force applied at the platform will travel down the core face and successfully remove a flake or blade.

Once a suitable platform has been established it is necessary to shape the core face in order to establish a ridge running perpendicular to the platform. This ridge will act as a guide for the applied force and serve to regulate the shape of the removed flake or blade. This can be achieved by initially applying force to the platform in order to remove a single large flake and establish a corner perpendicular and at right angles to the platform (Crabtree 1968: 460). Following this, a second flake is removed which leaves a flake-scar that intersects the first flake-scar (Crabtree 1968: 460). From these two removals there should be a single ridge running down the face of the core from which the first blade may be produced. If the ridge is curved or irregular the ridge can be straightened by a series of transverse removals across the line of the ridge. The resulting 'crested blade', or '_Lame a Crête_' (Crabtree 1972: 72), once removed should leave two straight ridges running perpendicular to the core platform, and enable blade production to proceed. If, during the course of straightening the ridge, an overhang is created at the top of the core this platform overhang must be removed through either a lateral blow or a blow delivered underneath the overhang directed upwards toward the platform edge (Crabtree 1968: 460).

Whilst the details of blade production may vary according to variations in core type(Crabtree 1968: 461 - 462) the basic principles outlined above apply. Similarly, the actual techniques involved in removing blades can vary according to the methods used to apply force. Percussive techniques can serve to remove blades, although the highly controlled blade production outlined by Crabtree (1968) uses pressure techniques. The significance of pressure in removing blades from a core lies in the degree of precision with which force can be placed and exerted on the platform. Using a pressure tool a high degree of control can be exerted in determining the thickness of removal:

> 'The thickness of the flake is governed by the seating of the pressure tool on the platform. If it is set close to the edge at the top of the core, a thin blade will result. If it is set far back, the blade will be thicker.'
>
> (Crabtree 1968: 464).

The use of pressure in the manufacture of blades can be assisted by the preparation of the core platform. By grinding or scoring the platform surface close to the core edge the pressure applicator can be seated on the platform, in readiness for blade removal, without the risk of slippage (Crabtree 1968: 463, 1972: 84) and, by strengthening the platform, with less risk of the platform collapsing when force is applied. The strengthening of a platform can also be achieved through the isolation of the area to receive force, with the removal by grinding of a series of small flakes on either side. This latter technique may equally apply to percussive techniques of blade removal. Such strengthening of a platform may be important since in the event of a platform collapse the force may be ineffectively directed and result in an imperfect blade removal.

iii) <u>Optional primary trimming</u>

Collins associated this stage with either the shaping of flakes or blades into tools for use, or the additional working of a core in readiness for flake/blade production.

With regard to the products resulting from core reduction, that are destined for tool manufacture - or 'blanks' (Bradley 1975: 5; Crabtree 1972: 42), these may undergo a series of removals, using a mixture of techniques, prior to achieving their final tool shape. Simple retouch techniques at this stage may result in a variety of tools. However, more complex tools may undergo shaping using a combination of retouch, thinning and pressure techniques. We might, for example, consider the use of the micro-burin technique for segmenting blades (Crabtree 1972: 76). Blades are notched from one margin prior to the application of a blow to separate one end of the blade from the rest. Two stages are involved: the initial notching, and the separation of the micro-burin. The conversion of the blank passes through a two-stage process in which a 'pre-form' (Collins 1975: 22; Crabtree 1972: 85) is created, prior to the production of the end product. In the case of micro-burins, the process is generally extended to a third stage of shaping by retouch in the production of a microlithic tool.

iv) Optional secondary trimming and shaping

As discussed above, blanks may pass through several stages of shaping prior to their completion as tools. Blanks, once initially shaped into a pre-form, pass into this optional stage of secondary shaping. Collins (1975: 22) identifies this stage as the point where strong 'stylistic', or design constraints influence the shaping procedure.

v) Optional maintenance and modification

Of all the stages identified by Collins the maintenance and modification activities in lithic reduction sequences represent the most potentially informative with regard to the degree of economization. We have seen that in the manufacture of a lithic industry a variety of techniques may be employed. When comparing different technologies it may be possible, in a general sense, to argue that one technology is relatively more efficient in the use of a raw material than another. For example, other things being equal, a core and blade technology may be regarded as more efficient and more controlled than a bipolar technology (Crabtree 1972: 42; White 1968). Similarly, the increased use of pressure techniques for blade manufacture may well represent a more efficient technique when compared to percussive blade manufacturing. From this we might seek to identify increased usage of pressure techniques as an index of flint economization. However, within a given set of manufacturing techniques the degree of maintenance should serve as an effective index of economization, and can be applied to the stages of production from the initial reduction of a core through to the eventual discard of stone tools.

In our discussion of the steps associated with the manufacture of blades from prepared cores we identified some of the techniques which may be employed in minimizing the risk of failure in the removal of blades. Whilst production failures can arise from the collapse of platforms, other factors may also induce misdirections in the force applied. Many microcrystalline or cryptocrystalline materials contain nonconformities in their internal structure, which may not be immediately apparent from external examination of a raw material mass. Lines of weakness, or impurities in the material can deflect the line of force and give rise to the premature termination of a flake or blade removal. When this occurs the resulting flake or blade may terminate in a hinge or step fracture. A hinge fracture at the distal end of a flake terminates the flake 'at right angles to the longitudinal axis and ... is usually rounded or blunt.' (Crabtree 1972: 68). A step fracture is 'a flake or flake-scar that terminates abruptly in a right angle break at the point of truncation.' (Crabtree 1972: 93). Both of these types of production failure can leave scar profiles upon the face of a core which inhibit or prevent the subsequent controlled removal of blades. As such they present a problem to the flint knapper wishing to extend the utility of the core. The cleaning-off of prominent hinge or step fracture scars from a core face demands the careful removal of a large flake which incorporates the scars on its dorsal surface (Crabtree 1972: 69). In striking off a 'core face recovery flake' the force needs to be applied relatively deep on the platform edge in order to ensure that the removal will be sufficiently broad and thick to clean off the unwanted features.

In contexts where raw material supplies are constrained by considerations of cost we can expect that, other things being equal, greater efforts will be made to extend the utility of a core through the use of core face recovery techniques than in contexts where raw material supplies are not constrained by cost. From this it follows that as the costs of procuring raw materials increase then, so too, the use of core face recovery techniques should also be extended.

In extending the utility of a core for flake/blade production attention is also required in the maintenance of platforms. We have previously identified the manner in which platform overhangs can be removed. During the course of blade/flake removal the negative bulbar scars, just below a platform edge, form platform overhangs which inhibit continued blade production. Consequently, the extension of a core's use-life will demand the periodic removal of platform overhangs.

Similarly, as a core is reduced the successive removal of blades can leave concentrations of small, irregular scars around the platform edge. Periodically it may be necessary to rejuvenate the platform in order to clean off these irregular features. Rejuvenation of a platform may also be necessary in order to maintain the required angle between the platform and the core face. To achieve these ends various techniques may be employed. One of the most frequently observed techniques is to strike the core face just below the platform edge in the same plane as the platform. In this way the old platform may be completely removed either by a single, or several removals, leaving a fresh platform in its place.

Under certain circumstances it may be desirable to create an alternative platform with which to continue blade/flake production. Once again, a variety of techniques may be employed. Crabtree (1968: 466) has discussed the technique whereby the distal end of a core can be removed during the course of reduction:

> 'As the proximal end of the core becomes smaller, the platform areas become isolated; when this happens, it is very easy to position the (applied force) ... far from the edge of the core, causing the blade to be thicker than normal. The thicker blade allows the force to spread, and this will sever the core ....'.

The resulting plunging blade carries away the distal end of the core (see Crabtree 1968: fig. 9d). Whilst under certain circumstances the removal of a plunging blade may be counted as unintentional, the technique may, however, serve to create a fresh platform with a suitable oblique angle to the core face.

Through a combination of core face and platform rejuvenation removals the utility of a core may be extended. Consequently, the continued reduction of cores will serve to ensure that once a core is finally discarded it will have been significantly reduced in mass. Under conditions of constrained raw material supplies we might expect, therefore, that discarded cores shall be, other things being equal, smaller than under conditions where such constraints do not apply. From this we might expect that in cost-distance related procurement systems the average size of discarded cores will decrease with increased distance from source. Furthermore, we would expect that such a pattern would correspond with increasing evidence of the various by-products of core maintenance and rejuvenation.

Although Collins (1975: 23) does not discuss core maintenance activities he does consider the role of maintenance in the extension of tool use-life. He distinguishes between maintenance, where the original attributes of a tool are restored, and modification, where a worn or broken tool is transformed into a new tool type. We have previously identified the latter process as recycling.

Recently, Morrow and Jeffries (forthcoming) have sought to distinguish between the effects of differing procurement mechanisms on the basis of measurements of tool exhaustion. Their analysis proceeded upon the expectation that tools manufactured upon non-local materials would, under a cost-distance related procurement system, exhibit higher levels of maintenance and resharpening than those manufactured from local materials. We can adapt their approach and suggest that in a cost-distance related system of procurement the degree of maintenance of tools manufactured from the same material should increase with increasing distance from raw material source.

Binford and Stone (1983) have recently outlined similar expectations for the use of 'expensive' raw materials at the James Range East site. As previously discussed, the absence of mechanically suitable raw materials within the foraging radius of the James Range East site may have led the site occupants to undertake task group organized procurement journeys beyond the foraging radius. The costs incurred in acquiring raw materials might be expected to be reflected in increased attempts to maximize raw material utility through the increased resharpening and maintenance of tools. As noted by Binford and Stone,

> 'It would be interesting to know if at James Range East there was a more exhaustive use of adzes of exotic material than was observed at Puntutjarpa; we would expect such a pattern.'
>
> (1985: 153).

The quantification of the degree of maintenance applied to categories of stone tool would ideally be achieved through the recognition of debitage which could be confidently associated with maintenance activities. However, the resharpening flakes derived from, for example, adzes or endscrapers may be difficult to identify with a high degree of precision or confidence. For other categories of stone tool, such as flaked axes, the by-product of resharpening may be more distinctive. It may, however, prove more economical to approach the study of tool maintenance, where applicable, through the measurement of the size parameters of tools. Other things being equal we could expect that within a given category of tool as the degree of maintenance increases then the average size of discarded tools should decrease. From this we can see that under conditions of cost-distance related procurement the average sizes of discarded tools of a given type should decrease with increasing distance from source. Clearly, these measures of tool maintenance would only be applicable where the tools in question could be effectively maintained through resharpening or additional reduction.

A number of authors have sought to examine the degree of raw material economization in the context of blade production systems through the measurement of various blade attributes. Following the experimental work of Sheets and Muto (1972), researchers dealing with Mesoamerican blade industries (Sheets 1978; Sidrys 1976) have employed the ratio of the combined blade margin lengths to blade weight as an index of raw material maximization, and examined the effects of distance upon the index. As noted by Sheets and Muto,

> 'the prismatic blades in the Maya lowlands during the Classic period (A.D. 300 to 900) are consistently thinner and narrower than the blades we produced ... probably because obsidian had to be transported over long distances (often over 300 km). However, at Chalchuapa, El Salvador, only 50 km from a large obsidian outcrop, the prismatic blades are comparable to those described in this report.'
>
> (1972: 633).

Similar patterns have been noted by White and Modjeska (1978: 29) for variations in the sizes of axe blades in the Tumbudu River valley in New Guinea (fig. 8). In this case the size of blades decreases with increasing distance from source partly as a function of the constraining effects upon levels of maintenance of an exchange system.

In examining the degree of raw material maximization in Cycladic Neolithic and Bronze Age blade production Torrence (1979) utilized the mean blade length/weight ratio as an index of techno-economization. What is clear is that, providing a particular index can be justified for use as measurement of economization, we would expect to find increasing raw material maximization associated with blade production with increasing distance from source where distance constrains procurement.

Discussion

Armed with a variety of potential measures designed to examine levels of raw material economization in a lithic production system the lithic analyst may proceed with the task of distinguishing between procurement mechanisms that impose differential costs of obtaining raw materials, and those which do not impose such differential costs. Where it can be demonstrated that distances from raw material sources do not correlate with measures of economization then the discussion of curation can proceed on the premise that curation levels reflect the need for efficiency in the scheduling of technological and subsistence activities.

As previously discussed, curation, as a response to the need for efficiency in the scheduling of activities, carries important implications for the analysis of inter-assemblage variability. Curation reduces the regularity of association between discarded tools and their contexts of manufacture and use, and serves, therefore, to reduce levels of inter-assemblage variability (Binford 1976: 347). Consequently, the interpretation of site function within heavily curated technologies demands that consideration is given to the association of production and maintenance debris, as well as of tool inventories (Binford 1976: 344 - 345). Such considerations are of particular importance since we would expect curation levels, and the range of site types, to be greatest in logistically organized societies. The separation of technological and subsistence activities in order to maximize subsistence time and minimize the risks of failure will serve to ensure that the preparation of technology used for subsistence procurement will take place at either residences or field camps (Binford 1976: 345) as opposed to locations where the performance of subsistence procurement activities is undertaken (i.e. hunting camps or kill sites). At these latter sites technological activity might be expected to be associated with the problems of coping with boredom (Binford 1978b) - such as light craft activities - and not with the gearing-up of subsistence technology.

We might expect, therefore, that the archaeological record generated by a logistically organized system would exhibit marked differences in the sorts of manufacturing and maintenance debris associated with, on the one hand, residences and field camps and, on the other, special purpose locations. In the former sites we would expect to observe large amounts of debris deriving from the gearing-up of resource procurement technology not directly associated with the tools that were being produced. At the latter sites we might expect to observe manufacturing debris associated with discarded, expediently manufactured tools used for minor craft activities. Special purpose sites may exhibit discarded hunting tools, but these might be expected to derive from broken tools.

Consideration of the relationships between evidence for production, maintenance and discard patterns can, therefore, inform us about site functions. At a more general level, the organizational dimensions of lithic technology can be seen to be responsive to the broader context of subsistence behaviour. Embedded procurement strategies, as discussed previously, produce patterns of raw material input that reflect the mobility scale of hunter-gatherers. Consequently, the analysis of raw material distributions can provide the lithic analyst with a powerful methodological tool for examining the scale of prehistoric subsistence patterns. However, if the availability of spare transport capacity is spatially/ temporally differentiated we might also expect to see an imbalance in the representation of raw materials. As will be examined later in this thesis, the differential occurrence of spare transport capacity may produce structuring in certain aspects of the lithic production sequence that present the lithic analyst with specific methodological challenges.

The analytical importance of differing raw material procurement strategies for the interpretation of lithic assemblages demands that approaches designed to differentiate between them be developed. Such an imperative is rendered even more crucial given the implications of non-embedded procurement systems for other technological strategies such as curation. We may, therefore, loosely paraphrase Renfrew (1969: 152) and observe that 'embedded procurement cannot be assumed; it has to be justified.'

4) <u>The structural dimensions of lithic technology</u>

In the earlier examination of hunter-gatherer resource exploitation it was argued that in terms of the relative constraining effects of risk and costs a contrast could be drawn between the exploitation of mobile versus non-mobile resources. It was suggested that, at a generalized level, the exploitation of non-mobile resources was constrained by the amount of energy available for resource procurement whereas the exploitation of mobile resources was primarily constrained by the availability of time. The contrast between exploitation strategies dependent upon non-mobile versus mobile resources was shown, in the discussion of forager and collector strategies, to influence mobility, settlement and scheduling behaviour. The high degree of time-stress associated with specialized, high latitude exploitation strategies arose from the spatially and/or temporally incongruous distributions of critical resources. Against the differing demands upon the scheduling of time for resource exploitation observed amongst foragers and collectors the organizational dimensions of lithic technology were seen as responsive.

Recently, Torrence (1983) has examined the relationships between time-stress and the structural dimensions of lithic technology. As indicated at the beginning of this chapter, the consideration of the rate of energy capture in exploitational strategies may have considerable explanatory importance for situations where the amount of time available for resource procurement is limited. Torrence's examination of time-stress and technological structure specifically emphasized the importance of the need for speed and efficiency in resource procurement tasks where time is limited. In one sense the discussion of efficiency in the scheduling of technological activities such as raw material procurement, manufacture and maintenance, and in the performance of resource procurement activities

activities will be differentiated in terms of target resources. Implements, being used upon resources incapable of significant motion, necessarily will be associated with the exploitation of plant resources and those animals whose mobility is relatively restricted. Examples of instruments would be digging sticks, or hammer-stones used for dislodging certain shellfish species from rock surfaces. Weapons, being used upon species capable of significant motion and designed to kill or maim species, will be associated with the exploitation of a variety of animal resources. Examples of weapons are spears, arrows and throwing sticks. Similarly, facilities will be associated with the exploitation of a variety of animal resources. In controlling or protecting a resource for man's advantage we can see traps, snares, fish weirs or hunting blinds as examples of facilities. Oswalt further divided facilities into tended and untended (1976: 26), depending upon whether they function with or without the presence of man.

If we now turn to the detail of Torrence's analysis of the relationships between time-stress and assemblage structure in terms of composition, diversity and complexity the implications of her approach for lithic research can be recognized. In particular it is possible to recognize those areas where the implications of time-stress for assemblage structure carry implications for the study of technological organization.

a) Assemblage composition

As stated by Torrence (1983: 13) in examining the relationship between time stress and the functional categories of tools (instruments, weapons, and facilities) we can seek to recognize the degree to which differing subsistant categories may be useful in reducing the time required in resource procurement. Oswalt's data (1976: 157, 173) reveals an interesting contrast in the potential can be regarded separately. However, between the separate spheres of technological organization and structure there are areas of mutual implication where the discussion of one has meaning and relevance for the other.

Torrence identified three dimensions of assemblage structure which could be related to time-stress: composition, being the functional categories of tools in an assemblage; diversity, being the number of tool types within functional classes; complexity, being either the average number of parts per tool or the total number of parts in a tool kit assemblage (13). Through an examination of these three dimensions it was argued that the relationship between the need for speed in resource procurement activities and technological structure could be identified. The extensive catalogue of ethnographic data concerning technology compiled by Oswalt (1973, 1976) provided the data base for systematically examining the role of time-stress in technological structure.

Oswalt (1973, 1976) developed a vocabulary which has proved useful in the analysis of technological structure (see Lustig-Arecco 1975, 1977). Oswalt's term subsistant is defined as 'an extrasomatic form that is removed from a natural context or manufactured and is applied directly to obtain food.' (1976: 46). In discussing subsistants a tripartite distinction was made between instruments, weapons and facilities. Instruments were defined as 'hand manipulated subsistants that ... impinge on masses incapable of significant motion.' (1976: 64), whilst weapons were defined as 'a form that is handled when in use and is designed to kill/maim species capable of significant motion.' (1976: 79). The final category, facilities, was defined as 'a form that controls the movement of a species or protects it to man's advantage.' (1976: 105). On the basis of these definitions alone it should be apparent that the roles of instruments, weapons and facilities in subsistence

Group	Lat.	INSTRUMENTS			WEAPONS			TENDED FACILITIES			UNTENDED FACILITIES			TOTALS		
		no.	tu.	$\bar{x}$.	no.	tu.	$\bar{x}$.	no.	tu.	$\bar{x}$.	no.	tu.	$\bar{x}$.	no.	tu.	$\bar{x}$.
TIWI	12	3	6	2.00	6	6	1.00	2	2	1.00	-	-	-	11	14	1.30
ANDAMANESE	12	4	8	2.00	4	31	7.75	3	12	4.00	-	-	-	11	51	4.64
INGURA	14	3	3	1.00	6	19	3.17	3	8	2.67	1	2	2.00	13	32	2.46
CHENCHU	16	7	13	1.86	7	26	3.71	6	16	4.00	-	-	-	20	55	2.75
NARON	19	2	5	2.50	5	19	3.80	3	5	1.67	2	11	5.50	12	40	3.33
ARANDA	24	4	7	1.75	4	21	5.25	7	10	1.43	1	4	4.00	16	42	2.63
OWEN V. PAIUTE	37	4	9	2.25	9	44	4.89	10	30	3.00	5	24	4.80	28	107	3.82
SUR. V. PAIUTE	42	7	15	2.14	9	27	3.00	19	41	4.56	4	14	3.50	39	97	2.49
TASMANIAN	42	3	3	1.00	3	3	1.00	4	8	2.00	1	1	1.00	11	15	1.36
KLAMATH	43	9	18	2.00	7	35	5.00	22	70	3.50	5	28	5.60	43	151	3.51
TWANA	48	4	7	1.75	12	70	5.83	19	96	5.05	13	64	4.92	48	237	4.94
TLINGIT	58	4	7	1.75	8	25	3.13	8	34	4.25	8	55	6.88	28	121	4.32
TANAINA	60	7	13	1.86	16	83	5.19	3	17	5.67	14	111	7.93	40	224	5.60
INGALIK	62	6	14	2.33	13	64	4.92	15	61	4.07	21	157	7.48	55	296	5.38
NABESNA	63	1	1	1.00	8	36	4.50	8	23	2.88	8	45	5.63	25	105	4.20
CARIBOU	63	3	12	4.00	10	39	3.90	13	37	2.85	8	30	3.75	34	118	3.47
ANGMAKSALIK	66	4	18	4.50	18	151	8.39	9	20	2.22	2	13	6.50	33	202	6.12
IGLULIK	69	3	8	2.67	20	142	7.10	8	27	3.38	11	48	4.36	42	225	5.36
COPPER	70	4	16	4.00	8	53	6.63	11	36	3.27	4	17	4.25	27	122	4.52
TAREMIUT	71	1	3	3.00	18	133	7.39	10	41	4.10	6	28	4.67	35	205	5.86

table.1

roles of instruments, weapons and facilities for the reduction of resource procurement time expenditure.

Instruments, in being used for the exploitation of non-mobile resources, are associated, by implication, with activities where time is not a constraining factor. Since non-mobile resources cannot escape, once located, their exploitation does not demand particular concern for maximizing the availability of time. Consequently, the use of instruments offers no particular advantages in terms of time maximization. As will be shown in the discussion of subsistant complexity instruments may offer certain benefits in terms of cost limitation, which may be a constraining factor in the exploitation of non-mobile resources.

Both weapons and facilities, however, may serve to maximize the availability of time in the exploitation of mobile resources. As discussed previously, mobile resources demand potentially high investments of time in their location and pursuit. For a hunter searching the environment for mobile resources any increase in the time taken to locate prey incurs additional risks of failure in the procurement of adequate resources. Technological investments which effectively increase the availability of search time are, therefore, potentially important. Untended facilities serve to maximize search time since they enable a hunter to search whilst they procure resources. In effect, untended facilities maximize search time by enabling several 'searches' to be undertaken concurrently (Torrence 1983: 16).

Tended facilities and weapons can serve to maximize pursuit time in a variety of ways. The exploitation of mobile resources using weapons demands that a hunter achieve an appropriate position with regard to the prey before the weapon can be used. Keene (1979: 77) has termed this positional relationship between hunter and prey as 'the critical distance' (Keene 1979: 377).

A number of factors may combine in determining critical distances. Species' behavioural awareness, the availability of cover, topography, wind direction to name but a few factors may variously increase or decrease the distance over which a hunter can be sure of an accurate strike.

As far as weapons are concerned critical distance may be influenced by a combination of the accuracy, flight characteristics (where appropriate), and power of the tool. Accuracy is demonstrably a crucial factor in the exploitation of mobile species. Based upon data presented in Prior (1968: 181) it can be seen (fig. 9) that the distance moved by Roe deer (Capreolus capreolus) after being shot with a .243 Winchester using a 100 grain bullet varies significantly according to the point of impact. Similar data has been presented elsewhere (de Nahlik 1959: 176-180) for Roe and Red deer (Cervus elaphus). In seeking to maximize pursuit time hunters must take care in hitting specific points of an animal's body, otherwise the prey may move a considerable distance thereby increasing the time required for pursuit.

For projectile technology accuracy will be influenced by the distance over which the weapon can travel in a predictable flight with sufficient force to inflict the desired wound. The enhancement of flight characteristics may be achieved through improved projectile design, as will be discussed below. Similarly, the power of delivery may be increased through the use of additional technology, such as bows or spear throwers. The important point here is that weapons can, through elements of design investment, increase the critical distance and effectively increase the availability of pursuit time.

Similarly, tended facilities which serve to reduce prey mobility or enable a hunter to operate at close range, such as hunting blinds, can reduce the time spent in pursuit. As Torrence (p. 17) has argued, tended facilities may be particularly important in the

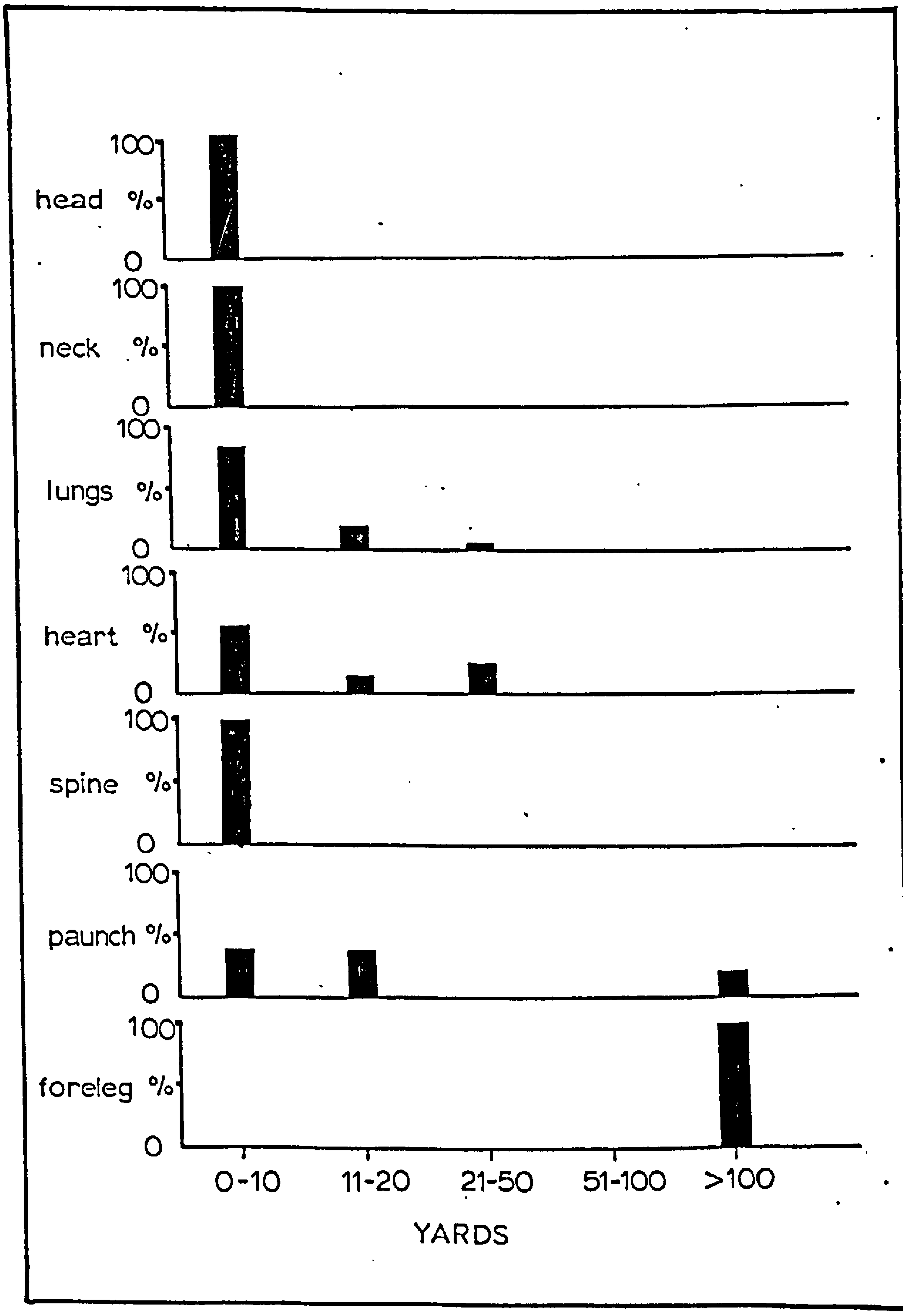

head
neck
lungs
heart
spine
paunch
foreleg
100
%
0
0-10
11-20
21-50
51-100
>100
YARDS

fig. 9

exploitation of aggregated species where large quantities of resources can be obtained in a relatively short time. When species are dispersed weapons may be relatively more important in procurement technology, although the use of tended facilities also demands the use of weapons (Torrence op. cit.: 17).

In examining the composition of assemblages associated with the exploitation of mobile resources Torrence (p. 17) has noted that the relative importance of tended and untended facilities as well as weapons can be understood in terms of the combined effects of the overall time-stress of the environment and the behavioural characteristics of target resources. The adaptive significance of untended facilities in maximizing search time can be seen in their increased usage in environments where time-stress is high. Untended facilities are seen to be increasingly important in high latitude environments where time-stress is increased. The decline in their relative importance in certain arctic environments is attributed to the high level of sea mammal exploitation in these contexts. The design of untended facilities which could function in the open sea is not generally feasible and so weapons assume a primary importance.

At a global scale the procurement of terrestrial mobile resources illustrates the compositional responses of technology to time-stress. As noted by Torrence,

> 'Near the equator where time is not limiting, small mammals are hunted largely with weapons and instruments, whereas in the far north, untended facilities, such as traps and snares, dominate the relevant tool kits. A similar pattern ... applies to large terrestrial mammals; as seasonality increases, tended facilities are brought more ... into ... the subsistence strategy.'
>
> (1983: 17).

The discussion of assemblage composition reveals important relationships between technological structure and subsistence strategies. In increasingly seasonal, time-stressed environments the adaptive benefits of facilities are reflected in their increased usage. As will be discussed below, the potential benefits of enhanced weapon design has implications for the diversity and complexity of subsistants.

In terms of lithic analysis the study of assemblage composition may present certain methodological challenges. Facilities may, in many instances, be difficult to recognize directly from the archaeological record. Many facilities, such as fish weirs or hunting blinds, incorporate organic items in their construction which may not survive in the archaeological record. Furthermore, facilities will frequently be located at some distance from centres of intensive lithic reduction. Given that the archaeological record of prehistoric hunter-gatherers is frequently influenced, in terms of prehistoric field research, by the recognition of lithic concentrations we may not be able to recognize facilities from existing data. The bison kill sites of the plains of North America represent one example where facilities have been recognized archaeologically, but these have the added benefit of huge quantities of bone remains to assist interpretation.

The lithic assemblage of prehistoric hunter-gatherers will, in compositional terms, provide evidence of weapons and instruments - the portable compositional items of subsistant technology. It may, however, be possible to infer some of the strategies used by prehistoric groups in seeking to control the distribution and/or movement of prey species in the environment. Such inferences will come from other sources of evidence, such as pollen data in the recognition of the controlled clearance of forest areas to manipulate prey species behaviour (Torrence 1983: 16). The recognition of such strategies may prove highly informative in terms of the overall level of time-stress associated with subsistence activities.

b) Subsistant diversity

In examining the diversity of subsistants the efficiency of a tool in the performance of a particular task is assumed to be related to the degree in which that tool is specifically designed for the performance of that task. Tools designed to perform specific tasks should be more efficient in the execution of those tasks than tools designed to undertake a broader range of tasks (Torrence 1983: 13). Given this assumption the degree of task specialization for tools should relate to the amount of stress upon technology for efficiency in task performance. Consequently, the performance of tasks where time-stress is high should be undertaken by a range of tools each with a specific function or task. It follows that with increasing task specialization tool kits should become more diverse (Torrence 1983: 13). We may therefore expect that the diversity of tool kits should be inversely correlated with the amount of time available for the performance of tasks.

The relationship between tool kit diversity and time-stress is complicated by the factors governing assemblage composition. As has been previously discussed, the relative contribution of different tool types will be determined by the degree to which different types present time saving benefits within subsistence strategies (Torrence op.cit.: 17). However, in general terms, the diversity of subsistants within a type will be primarily determined by the range of resource procurement tasks and the time-stress associated with subsistence activities.

As in the case of collector adaptations, subsistence strategies which emphasize the exploitation of a limited range of critical resources are subject to high levels of time-stress. In response, technology needs to be efficient in task performance. Consequently, the tools used in resource procurement are designed to be highly effective and efficient in saving time. Hunters in specialized environments use a diverse set of tools with each tool

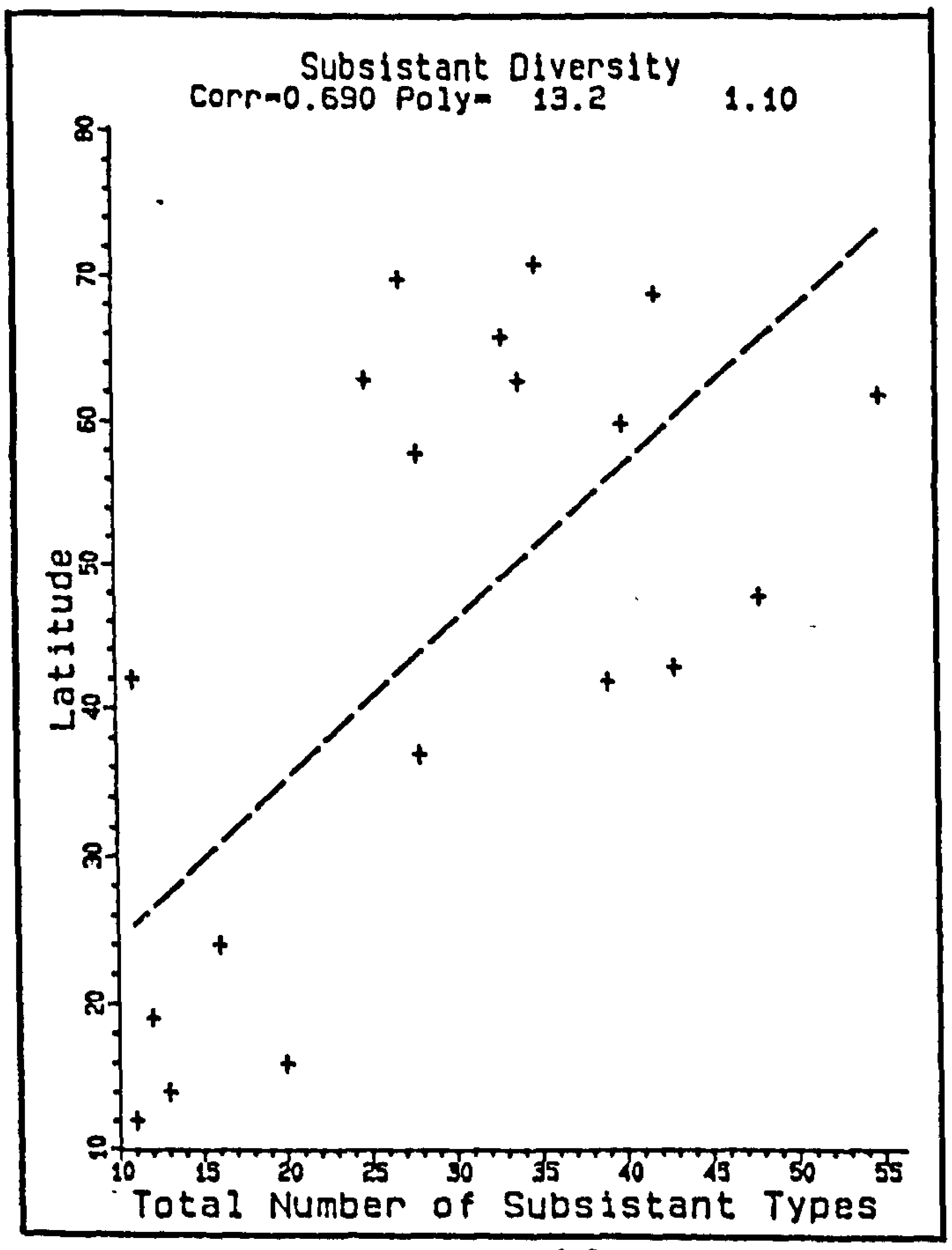


fig.10

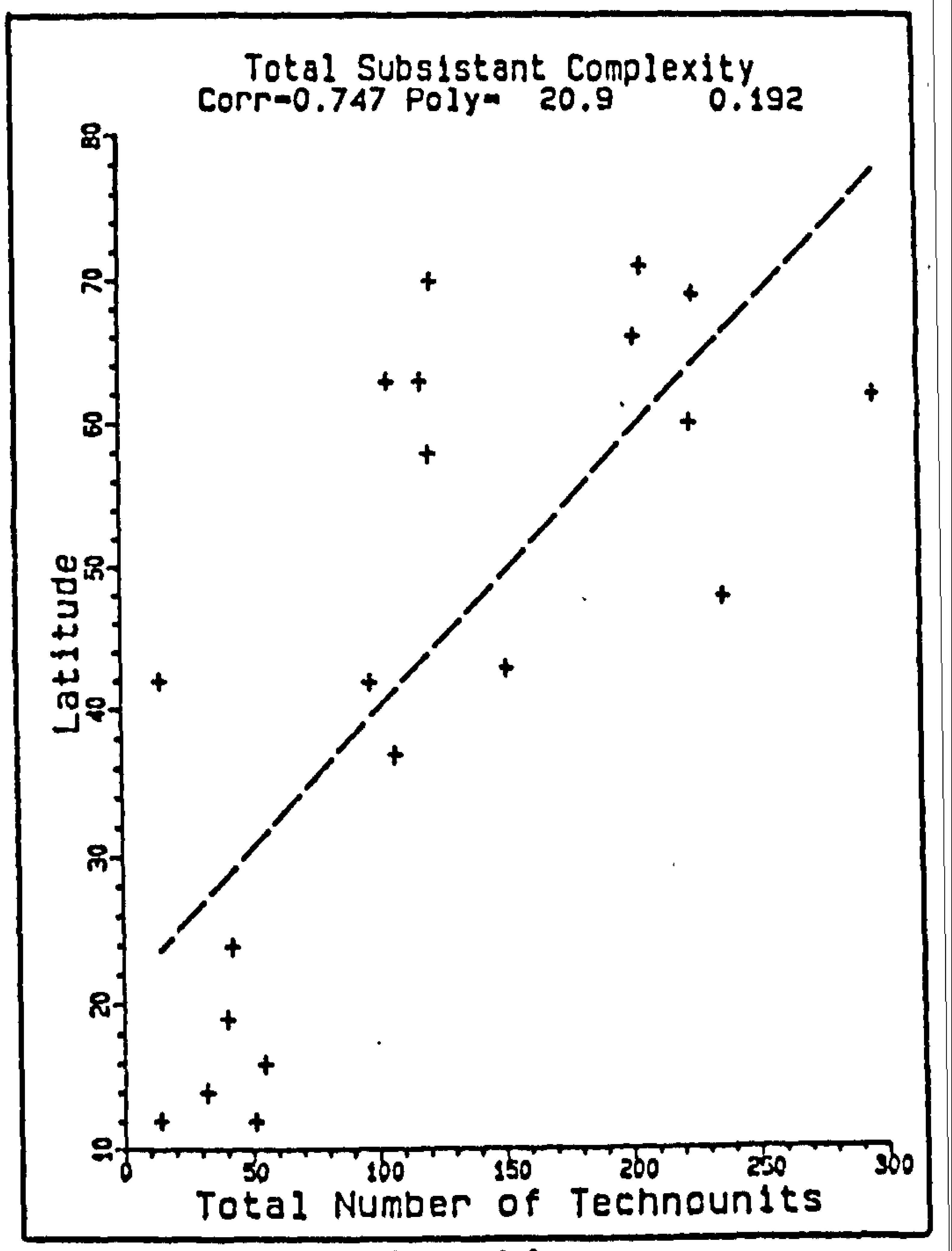


fig.11

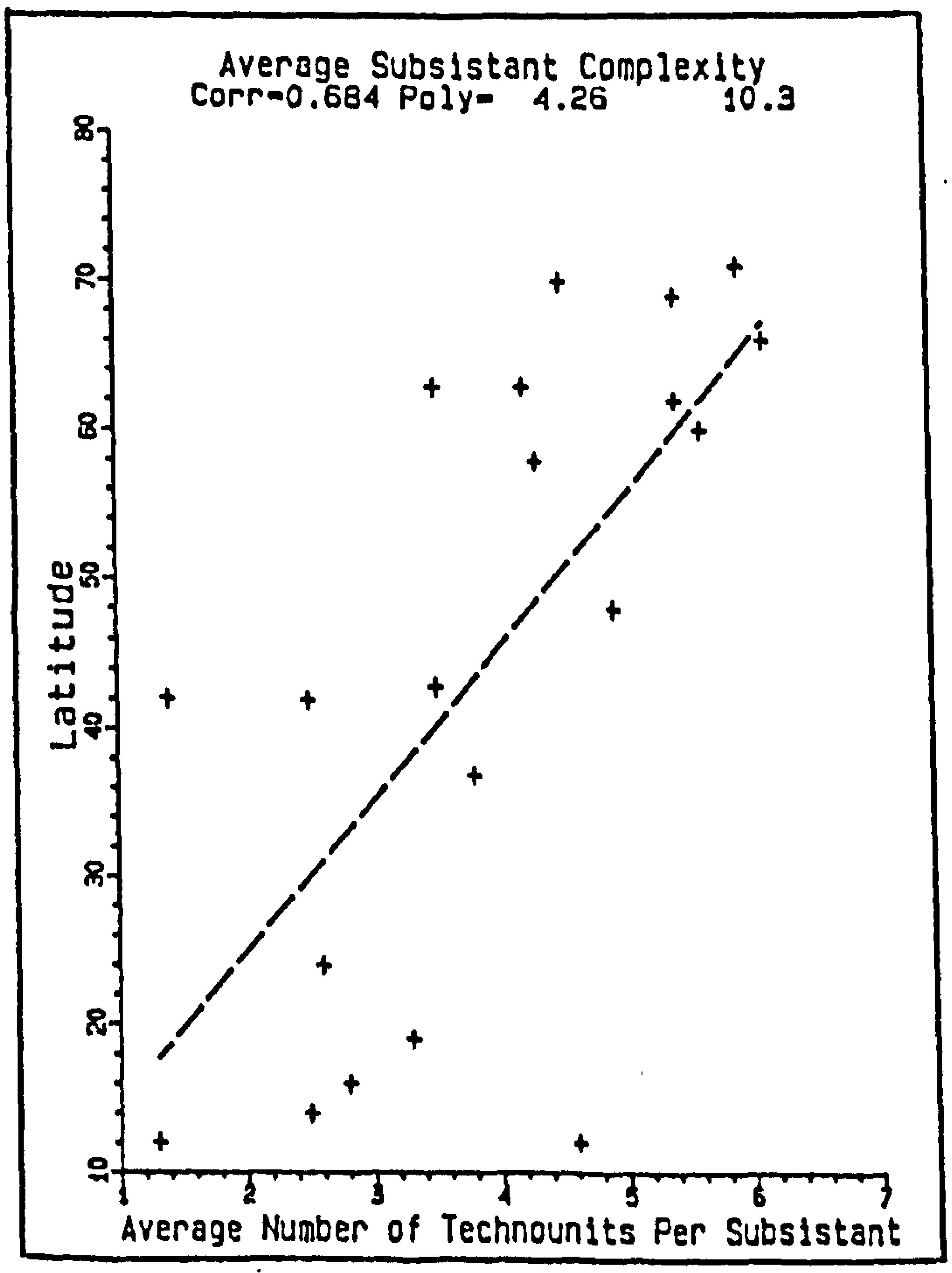


fig.12

being designed to perform a specific, precise task (c.f. Oswalt 1976: 102; Torrence 1983: 18). In contrast, the resource procurement demands of generalized environments involve less-time-stress. Forager strategies, at any one time, have a broad range of resource options available, including low-risk, non-mobile resources. Under these circumstances there is little to be gained through the use of subsistants designed for specific resource procurement tasks. Indeed, the use of highly task-specific tools in generalized environments may be regarded as 'maladaptive' (Torrence op. cit.: 18) given the broad range of potential resource targets which might be encountered. Hunter-gatherers in generalized environments, therefore, are better-off being equipped with a few general purpose tools capable of being employed in a wide range of tasks.

Torrence (p. 18 - 19) has tested the relationship between subsistant diversity and resource specialization, using latitude as an environmental index. The resulting positive linear relationship (fig. 10) confirms a significant ($r = 0.6903$; $p<0.01$) relationship between subsistant diversity and the degree of resource specialization. Given the relationship between resource specialization, time-stress and environmental distributions we can say that the diversity of subsistants does appear to increase with increases in time-stress.

c) <u>Subsistant complexity</u>

In examining the complexity of subsistants Oswalt (1976) devised the concept of the <u>technounit</u> which he defined as,

> 'an integrated physically distinct, and unique structural configuration that contributes to the form of a finished artefact.'
>
> (38).

Oswalt observed that measures of complexity may be applied at the level of the individual artefact or at the assemblage level. For the former complexity may be measured as the number of technounits which combine to complete the finished artefact (1976: 34). For the latter, two measures of complexity may be applied: it may be possible to arrive at an average number of technounits per tool by dividing the total number of technounits by the number of tool types, or, if preferred, it may be easier to simply use the total number of technounits (1976: 44). As noted by Torrence (p. 19), for archaeologists the latter measures may be easier to obtain since it might not be methodologically possible to assign each technounit to a specific tool type (complexity measured at individual tool level).

Once again, if the complexity of tools can be assumed to equate with efficiency in task performance then <u>we might expect to find tool complexity to be inversely correlated with the availability of time</u> (Torrence op. cit.: 13). From this we might predict that the subsistants of high latitude hunter-gatherers would be more complex than those of low latitude groups (Torrence op. cit.: 19). Using both the total number of technounits, and the average number of technounits per subsistant Torrence has examined the relationship between complexity and latitude (p. 19). With complexity measured as the absolute number of technounits a significant positive linear relationship was found (fig. 11: $r = 0.7470$; $p<0.01$), as was also the case using the average number of technounits per tool (fig. 12: $r = 0.6841$; $p<0.01$).

The increase in subsistant complexity observed with increasing latitude can only be partially understood in terms of the manufacture of tools using more technounits. As previously noted, assemblage composition may vary latitudinally according to the degree of time-stress, the nature of target resources and the time saving benefits of differing subsistant types. Between subsistant types complexity varies according to the degree in which investments in complex tools will serve to maximize the availability of time. Instruments, being associated with the exploitation of non-mobile resources, are necessarily used in procurement activities that involve the least amount of time-stress. As such, there are few benefits concerning time-saving to be made in the use of complex instruments. Consequently, instruments tend to be relatively simple in their construction. In terms of the average number of technounits per instrument their complexity varies between, for example, 1.9 for exploiting plants, 2.7 for exploiting small terrestrial mammals, and 3.0 for those used in exploiting fish (Torrence op. cit.: table 3.3).

Weapons, on the other hand, are associated with the exploitation of mobile resources where time-stress may be high. As noted earlier, weapons may be designed in order to maximize the pursuit time available to groups. The use of complex weapons can effectively contribute toward the task of reducing time spent in capturing mobile resources. Their average complexity varies between 3.5 for exploiting birds, 5.3 for exploiting large terrestrial mammals, and 11.1 for exploiting marine mammals (Torrence op. cit.: table 3.3).

As indicated previously, untended facilities offer the greatest benefits of time maximization in that they enable concurrent searches to be made. Therefore, the investment of time in manufacturing complex untended facilities offers considerable adaptive advantages where time-stress is high. The average complexity of untended facilities varies from 4.6 for those used in exploiting waterfowl, 5.9 for exploiting terrestrial mammals, to 7.1 for those used upon fish (Torrence op. cit.: table 3.3).

The observed increase in subsistant complexity with increased latitude can be seen to be a reflection of both the increased numbers of technounits per tool and the effects of latitudinal variations in assemblage composition. In other words, we can see that 'the two dimensions of composition and complexity are very much interdependent.' (Torrence 1983: 19).

Within subsistant classes the nature of target resources also contributes to systematic variations in tool complexity. Oswalt (1976: 101) noted that tools used in the exploitation of aquatic species are consistently more complex than their functional equivalents in the exploitation of terrestrial resources. Torrence (p. 20 - 21) has discussed the significance of the observed differences in complexity of tools used upon aquatic versus terrestrial species. She has suggested that tools used upon aquatic prey need to meet the additional time constraints of retrieval. The retrieval of prey from water is argued to be a more complicated task than is the case with terrestrial resources. For example, once a seal in the water has been hit by a spear or harpoon retrieval of the prey must be rapid in order to prevent it from submerging or sinking. The hunting of seal through holes in the ice is also fraught with the problems of the stricken animal moving away under the ice cover. Similarly, as any dedicated fisherman will testify, the hooking of a large carp or pike represents only the first stage of a potentially protracted and difficult process of successfully landing the prey. For hunter-gatherers the need to ensure retrieval gives rise to the design of tools with elements, such as barbs, lines, floats etc. that serve to retain the prey and assist in retrieval.

The recognition that additional technological inputs may serve to reduce time spent in pursuit and in retrieval is important when we are considering tool complexity. Whilst the relative complexity of tools may serve to provide archaeologists with clues to the functions of tools in assemblages (Torrence 1983: 20) the important point here is that the complexity of tools within a functional class may reflect additional time constraints arising from the level of risk associated with prey retrieval. Archaeologically, such considerations may be of significance when examining the complexity of particular tool types from assemblages of different periods. Alterations in vegetational cover may variously serve to increase or decrease the level of risk in prey retrieval when hunting mobile terrestrial resources. Variations in the complexity of weapons associated with the hunting of terrestrial resources may, therefore, reflect changes in the difficulty of retrieving prey. More complex weapons could assist in limiting the risks of a wounded prey avoiding capture, either through ensuring that the animal is sufficiently injured so as to reduce mobility, or through providing an adequate blood trail to assist tracking (de Nahlik 1959: 175). The design of projectiles with a number of barbs, for example, may ensure that the weapon remains lodged in the animal thereby keeping the wound open and causing maximal haemorrhaging.

d) Weapon design: complexity, reliability and maintainability

It has been suggested that weapons may be designed so as to maximize the time available for pursuit and minimize the time spent in retrieval. As mentioned previously, the enhancement of projectile design can serve to increase the critical distance for hunting. The flight characteristics of projectiles may be improved through ensuring that the balance and symmetry of the tool are maintained. Projectiles with barbs designed to retain or maximize injuries to prey might be expected to exhibit improved flight characteristics when the barbs are designed to give the weapon a balanced and/or symmetrical profile. However, the adaptive benefits of design elements such as barbs does not, of itself, immediately imply increased complexity as measured by technounits. For example, a projectile which incorporates barbs as part of its design may be manufactured from a single piece of material, such as antler or wood. In terms of technounits such a design would be relatively simple in comparison with a projectile where barbs made individually are combined with a separate shaft, using a variety of hafting techniques (Keeley 1982). The barb elements of 'simple' weapons can be just as effective in terms of balance and symmetry as with composite weapon designs. In seeking to understand the reasons underlying the manufacture of composite, complex weapons we need, therefore, to consider the potential adaptive advantages which might be associated with such a technology.

In a recent paper, Bleed (n.d.) has discussed the design strategy of hunting weapons and identified the characteristics of contrasting technological systems. In his discussion Bleed drew a contrast between 'reliable' and 'maintainable' systems. Reliable systems were characterized as being manufactured in such a way so as to ensure their ability to function. As such they are frequently designed with redundant or standby components which are present to perform the same task. In the event of an individual component breaking, the redundant components can perform the task without the need for immediate replacement. Maintainable systems, on the other hand, are designed so that, if broken, they can be easily and quickly repaired. The characteristics of maintainable systems include, what Bleed terms, 'a series design' where each component performs a unique task. As a result, the failure of any component in maintainable systems results in the failure of the whole system. Bleed notes that the contrasting characteristics of reliable and maintainable systems carry implications for the scheduling of manufacturing and maintenance operations.

Maintainable systems tend to exhibit no clear separation between the times when they are in use and are being maintained or repaired. They are maintained and repaired when needed. In contrast, reliable systems tend to exhibit a distinct separation of manufacturing and maintenance time from the times when they are in use. If we regard reliable and maintainable systems as distinct and mutually exclusive organizational alternatives then we can see that the scheduling characteristics which served in contrasting collector and forager strategies appear to match those which distinguish reliable and maintainable systems. On the one hand, collector strategies respond to time-stress by organizing technological activity into distinct and separate periods from those given to subsistence tasks. Foragers, on the other hand, tend to combine periods of technological and subsistence activity.

However, it may be more productive to regard reliable and maintainable systems as organizational variables which may, depending on circumstance, be used in combination thereby avoiding an unnecessary dichotomy between the two. In this sense composite, complex weapons may be regarded as reliable and maintainable in their design. As previously discussed, the manufacture of projectiles using composite barbs may exhibit redundancy in the replication of technounits designed for the same task. At the same time, such weapons might be maintainable in as much that broken barbs could be easily replaced. This would serve to contrast complex, composite projectiles from those manufactured from one complete piece of material. The latter might be regarded as reliable in their design, but not as maintainable as composite projectiles.

In terms of the adaptive benefits offered by weapon design the production of reliable and maintainable composite tools might be highly significant where the subsistence strategy of hunter-gatherers is time-stressed, but where the separation of technological and subsistence activities cannot be effectively planned. We might envisage such circumstances arising in environments exhibiting seasonal fluctuations in primary production but lacking the regularized aggregation of mobile resources. Hunter-gatherers in such environments may solve the problems of over-wintering by remaining active in the procurement of dispersed mobile resources throughout the winter period (Binford 1980: 15). The resulting continuity in subsistence activities would impose a continuous demand for efficient, reliable technology. In the absence of periods where stored resources could provide the time for gearing-up such technology would also need to be maintainable. Complex, composite weapons could, therefore, provide the optimal solution.

In contrast, reliable technologies would be appropriate as a technological response where the scheduling of subsistence and technological activities into distinct periods can be achieved. As previously indicated, the occurrence of regularized resource aggregations may provide the necessary conditions for such scheduling behaviour. Similarly, maintainable technologies will be appropriate where time-stress is low and technological activities can be undertaken expediently.

Given the perspectives offered above we can see that the complexity of subsistants will not only reflect assemblage composition and time-stress, but also the constraints arising from differing scheduling behaviours. For archaeologists the recognition of the multivariate nature of factors influencing assemblage structure provides the challenge of relating tool data to the subsistence and scheduling organization of prehistoric hunter-gatherers. Furthermore, the presence of tools designed to be efficient, reliable and maintainable in the archaeological record presents lithic analysts with specific methodological challenges in interpretation.

It has been recognized (Keeley 1982: 798 - 799) that the hafting of tools may be an important factor in considering the role of curation and its effects upon the archaeological record. Certain types of hafted tool may be capable of repeated resharpening and maintenance. Scrapers, drills and axes, for example, may be hafted and subject to frequent maintenance. The working edges can have their use-lives extended and be subject to prolonged curatorial behaviour. Binford (1976: 348) has suggested that 'as curation increases, the relative frequency of technologically important items (in the archaeological record) will decrease.'. For hafted tools capable of resharpening the components which provide the working edges should, in general, conform to Binford's expectation. However, as noted by a number of authors (Gould 1980: 128 - 129; Grinnell 1923: 215; Keeley 1982: 800; Lee 1979: 218) the hafts of tools are frequently subject to higher rates of curation than the components which provide the working edges. In the case of complex, composite weapons many of the components may be relatively expendable in comparison with the haft. Where such weapons are designed for maintainability and reliability the replacement of broken components may be the equivalent to the resharpening of tools such as hafted scrapers. Therefore, the frequency of occurrence in the archaeological record of broken components, such as barbs, may increase as curation increases. The key factor here is that in discussing rates of curation we need to distinguish between the object of maintenance (i.e. the complete tool including the haft) and the means of maintenance (i.e. replacement of components or resharpening/reshaping). Such considerations may be particularly important when considering diachronic patterning in tool assemblage variability. Changes in technological strategies towards a greater emphasis upon reliable and maintainable tools may well generate significantly higher proportions of certain tool components in the archaeological record associated with increasing rates of curation. For the archaeologist, the accurate interpretation of such changes through time will, in part, depend upon an understanding of the level of tool complexity and of the functions of tool components.

Chapter Summary

In this chapter an attempt has been made to integrate perspectives on the organizational and structural dimensions of lithic technology with our current understanding of hunter-gatherer subsistence, scheduling and mobility strategies. In general terms the organization and structure of technology has been argued as being responsive to the various constraints arising from the broader context of hunter-gatherer adaptations. The organization of technology has been shown to be primarily constrained by the degree of stress for efficiency in the segregation of technological and subsistence activities. Amongst contemporary hunter-gatherers a contrast has been drawn between groups whose subsistence activities are limited by the availability of energy and those limited by time. In terms of lithic procurement, manufacture and maintenance activities the need for avoiding conflicts with time required for subsistence activities is greatest amongst time-stressed groups. Amongst time-stressed collectors we see the adaptive benefits of embedded procurement and curation as strategies for avoiding conflicting time allocation in technological and subsistence activities.

The contrast between energy- and time-stressed adaptations has been shown to be informative concerning the dimensions of technological structure. Amongst contemporary hunter-gatherers measures of assemblage composition, diversity and complexity are seen to correspond with the degree of time-stress in the performance of subsistence tasks. Amongst energy stressed foragers the investment of additional inputs of time and energy into the manufacture of functionally specific, complex tools offers few benefits and may, in some instances, actually prove maladaptive. In contrast, for time-stressed collectors the use of functionally specific, complex tools offers benefits in terms of minimizing risk in food procurement through maximizing the availability of time.

Archaeologically, the implications of contrasting technological strategies offer a variety of avenues for investigating prehistoric subsistence, scheduling and mobility patterns through analyses of lithic assemblages. This chapter has drawn attention to some of the approaches which might be adopted by lithic analysts in investigating assemblage organization and structure.

Chapter Three:

Environment and chronology of the Mesolithic of mainland Britain

Introduction

The Mesolithic of the British mainland spans the period between the replacement of late-glacial hunting technologies by those industries belonging to the north European 'Maglemosian technocomplex' (Jacobi 1978a: 295) to the appearance of industries associated with the economic patterns incorporating the 'novel resources' (Dennell 1983) of the Neolithic midway through the fourth millenium. This period coincides with some of the most dramatic environmental responses to the amelioration of climatic conditions following the end of the Devensian glacial epoch. Although the processes which initiated the retreat of the northern ice-sheets may have begun several thousands of years prior to the final replacement of open tundra vegetation by birch, pine and hazel forest cover in England (Mellars 1974: 77) the first appearance of Mesolithic technologies and associated exploitation patterns would seem to be coincidental with these vegetational (and faunal) changes, marking the boundary between pollen assemblage zones III and IV (Godwin 1940, 1975).

Chronologically, the replacement of late-glacial industries by those characterized by broad, obliquely blunted points, isosceles triangles, core-axes, end-scrapers and burins does not occur synchronically throughout England. In southern England the earliest dates associated with Mesolithic industries come from the sites at Thatcham (Churchill 1962; Wymer 1962). Dates of 8415 ±170 b.c. (Q - 659) and 8080 ±170 b.c. (Q - 658) clearly associate Mesolithic industries with the exploitation of a woodland or woodland margin fauna (Bos, Red deer and wild Pig) late in the ninth millenium. In contrast, no ninth millenium dates have come from Mesolithic sites in the north. Instead, from the site at Anston Cave, South Yorkshire (Mellars 1969; White 1971), a series of three radiocarbon dates ranging from 7990 ±115 b.c. (BM - 440 A) to 7800 ±110 b.c. (BM - 440 B) place a typical late-Devensian 'Creswellian' industry of backed blades and a shouldered point associated with bones of reindeer and arctic hare in the first quarter of the eighth millenium.

Whilst doubts have been expressed concerning the accuracy of the Anston Cave dates (Mellars 1974: 74-5) a recent re-examination of pollen spectra from late ninth and eighth millenia contexts in England (Jacobi 1978a: 299) led to the conclusion that the replacement of tundra vegetation was, in comparison with southern England, delayed in the north. The earliest dates for Mesolithic industries in northern England of 7610 ±350 b.c. (Q - 1137) from Lominot 3 (Switsur and Jacobi 1975) and 7607 ±210 b.c. (Q - 14) and 7538 ±350 b.c. (C - 353) from Star Carr (Clark 1954) appear to correspond with dramatic increases in arboreal pollen after 7797 ±183 b.c. (Q - 155) at Scaleby Moss (Godwin et al. 1957), and slightly before 7636 ±200 b.c. (Q - 923) at Red Moss (Hibbert et al. 1971). These dates, combined with the faunal evidence from Star Carr (Fraser and King 1954) appear to confirm the first appearance of Mesolithic industries and the establishment of forest cover in northern England mid-way through the eighth millenium. From this we can see that although the opening of the Mesolithic period in England does appear to relate to the zone III - IV transition the timing of this transition varies in differing regions. Consequently, the convenient date of c. 8300 b.c. used by many authors (Hart 1981: 25; Mellars 1974: 77; Morrison 1980: 116) as marking the beginning of the Mesolithic period in England can be seen to be relevant for the south, but somewhat early for the north.

Following on from the previous point, the table showing the chronology of vegetational changes during the early post-glacial (table 2) must be regarded as being highly generalized in character. The complex chain of environmental adjustments to the post-glacial climatic amelioration which continues throughout the Mesolithic period undoubtedly proceeded at varying rates in the different regions. The potential importance of these changes in the natural environment to the understanding of industrial and behavioural variability in the Mesolithic demands that we bear the actual timing of these changes in mind when discussing Mesolithic archaeology. Failure to do so can produce confusion in the discussion of, for example, technological transitions in the Mesolithic period (see, for example, Morrison 1980: 134 - 146).

Environmental background

Towards the end of the Devensian glaciation the withdrawal of the ice-sheets from Europe and North America brought, in turn, significant changes in the natural environment. Adjustments in sea-levels, climate, vegetation and fauna initiated by the end of the glaciation continued throughout the post-glacial period. The rate and character of these changes does, however, appear to have varied, and the Mesolithic period in Britain coincides with some of the more dramatic alterations to the natural environment. It is against this background of environmental change that discussions of the hunting and gathering adaptations of the Mesolithic in Britain must be developed.

1) Sea-levels

The discussion of the effects of deglaciation upon relative sea-levels around Britain needs to consider two principal mechanisms. First, the release of vast quantities of water previously incorporated in the ice-sheets produced rapid eustatic rises in sea-levels at a global scale (Fairbridge 1961; Godwin et. al. 1958). The melting ice will have produced immediate increases in sea-level, and it appears that prior to c. 9000 b.c. relative sea-levels rose rapidly, producing large-scale incursions upon the land. In areas where the weight of ice had depressed the land, as was the case in Scotland, the maximum sea-level transgression appears to have occurred at the end of the glacial period, prior to about 10000 b.c. (Bishop and Dickson 1970; Peacock 1971). By the beginning of the Holocene period, however, the isostatic uplift of land masses freed from the weight of ice had served to greatly increase the coastal territories of many areas in Scotland and northern England. In the area of the North Sea relative sea-levels had dropped approximately 36.5 metres (Morrison 1980: 102). Evidence in the form of peat deposits and a barbed point, assignable to the Early Mesolithic, trawled from a depth of 36 metres off the Norfolk coast (Godwin 1933) appears to confirm that the southern basin of the North Sea formed a land-bridge between the east of England, northern France, the Low Countries and Denmark during the early post-glacial period.

Relative sea-level rises during the early post-glacial can be regarded as the outcome of competing eustatic and isostatic factors. The uneven distribution of ice in Britain during the Devensian produced widely differing rates of isostatic recovery. In southern England where there was little, if any, ice cover the development of shorelines during the post-glacial relates almost entirely to eustatic processes (Churchill 1965). In the north the competing effects of isostatic and eustatic processes upon relative sea-levels have produced a complex record of sea-level rises, transgressions and retreats which has been documented in detail in north-west England (Tooley 1974).

Tooley (op. cit.) has demonstrated that in north-west England the period between 7000 b.c. and 5600 b.c. saw a rapid rise in relative sea-levels. During this period sea-levels rose at an approximate rate of 1.8 cm/yr., with the exception of a period of relative sea-level stability between about 6400 b.c. and 6000 b.c.. Thereafter, the record of relative sea-level change exhibits a marked reduction in the rate of sea-level rise, punctuated by a series of short-term falls in sea-level. What is clear is that the earlier period, between about 7000 b.c. and 5600 b.c., witnessed a most rapid and prolonged rise in relative sea-levels. Given that the initiation of the sedimentological record examined by Tooley may not actually coincide with the initial rise in relative sea-levels we can say that during the earlier part of the post-glacial, prior to approximately 5600 b.c., the shoreline of the British mainland was subject to a prolonged increase in sea-levels.

The evidence from north-west England is of particular interest in that the period of rapid sea-level rise encompasses the dates suggested for the final formation of the Irish Sea (Tooley 1976; Simmons et al. 1981: 88) and for the severance of the eastern land-bridge in the North Sea (Kolp 1976) at approximately 5800 b.c.. This period appears, therefore, to have seen the progressive insularization of the present-day British mainland from both Ireland and the continental mainland.

This process of progressive insularization will have had a series of far-reaching implications both for the natural environment and for the human communities occupying the mainland of Britain. The previously mentioned discovery of an Early Mesolithic barbed point off the coast of Norfolk is matched by other, similar finds from the southern basin of the North Sea (Clark 1952; Godwin 1933). This evidence for Early Mesolithic activity on the North Sea land-bridge suggests that, at the very least, the extended area of the North Sea plain provided sufficiently attractive resources for periodic exploitation. Indeed, it has been speculated (Jacobi 1973: 245 - 46) that this region may have provided Early Mesolithic populations with 'a concentration of resources unparalleled elsewhere in northern Europe ...'.

However we view the resource potential of the North Sea plain during the early post-glacial period the evidence for progressive inundation over the period prior to 5800 b.c. suggests that during this period considerable areas of land available for movement and exploitation were lost. We can only speculate as to the immediate, short-term implications for communities living in and around the North Sea basin of the loss of this land and the resources that had previously attracted the attention of early Mesolithic groups. In the long term, however, even if we assume that early Mesolithic population levels remained stable over this period, the loss of land brought about through rising sea-levels immediately implies some magnitude of increasing population density in the areas bordering the North Sea basin.

Although the effects of rising sea-levels upon land-loss may have been most dramatic in the area of the North Sea plain prior to 5800 b.c. the same processes will have served to modify the coastline of mainland Britain in other regions. Rising sea-levels will have had varied impacts upon local shorelines according to the gradient of the coastal area and other aspects of regional geology and geomorphology. The flooding and inundation of low-lying plains and valleys will have served to initiate new, localized vegetational and faunal communities. As a number of authors have suggested (Jacobi 1973: 246; Simmons et al 1981: 120) the progressive insularization of Britain, and its final severance from the continent after about 5800 b.c. will have produced a marked increase in the ratio of coastline to dry land, thereby offering a different set of spatial relationships between coastal and inland resources.

Apart from the immediate implications for land-loss and shoreline development the rising sea-levels and progressive insularization of the British mainland conveyed other, far-reaching effects upon the natural environment in terms of climate, vegetational development and faunal community structure.

2) Climate

In recent years the contributions made to our understanding of post-glacial climatic changes through the analysis and interpretation of pollen, macrofossil remains and oxygen isotope studies have enabled a number of authors (Lamb 1966; Lamb et al. 1966; Taylor 1975) to reconstruct, with some confidence, the climatic history of Britain during this period. Whilst all such attempts must, of necessity, provide only highly generalized views of climatic trends the overall picture provided serves as a useful indication of the general pattern of Britain's climatic development.

Developing upon the previous work of Lamb et al. (1966), Taylor (1975) has provided estimates for average temperatures for lowland and upland (>500 m) regions of Britain, covering the period from 8000 b.c. up to the present day. Whilst this data, as presented, does not allow for regional variations it does present us with a potentially interesting basis for discussing generalized climatic trends in Britain during the early post-glacial period. Broken down into average summer, winter and annual temperatures for lowland and upland areas (fig. 13) a series of interesting trends can be noted.

It appears that the disappearance of ice cover from Britain at the end of the glaciation enabled a sustained and rapid climatic amelioration which saw annual average lowland temperatures of just below 0°C at 8000 b.c. rise to 12°C just after 6000 b.c.. These temperatures appear to have been subsequently sustained for the rest of the Mesolithic period, with only a slight fall after approximately 4500 b.c.. This picture, of rapidly rising average temperatures prior to 6000 b.c., is also reflected in the data for mean summer lowland and, more markedly, mean winter lowland temperatures. In the case of the latter, temperatures rise from -5°C at 8000 b.c. to just below 5°C at 6000 b.c..

The data for upland temperature regimes, whilst broadly corresponding with that for the lowland, consistently shows a less pronounced rate of temperature increase over the period 8000 b.c. to 6000 b.c.. Taylor (1975) argues that the retardation of temperatures in the upland would have related to the absence of the ameliorating influence of the Gulf Stream prior to the insularization of Britain, and, more generally, to the altitudinal effects upon the rate of upland climatic

CLIMATIC AND VEGETATIONAL SEQUENCE FOR LATE- AND POST - GLACIAL					
CHRONOZONES	GREAT BRITAIN	C14 YEARS b.c.	Blytt-Sernander Climate Periods	CLIMATE	VEGETATION
FLANDRIAN iiif	viib		Sub Boreal	Warm/Dry	Alder, Oak, Lime
		3200			
FLANDRIAN iie	viia		Atlantic	Climatic Optimum	Alder, Oak, Elm, Lime
		5500			
FLANDRIAN id	vi		Late Boreal	Increasing Warmth	Hazel, Pine + c) Lime b) Oak a) Elm
FLANDRIAN ic		7000			
FLANDRIAN ib	v	7500	Early Boreal		Hazel, Birch, Pine
FLANDRIAN ia	iv		Pre Boreal		Birch, Pine Forest
		8300			
LATE DEVENSIAN iii	iii	9000	Younger Dryas	Cold	Park Tundra
LATE DEVENSIAN ii	ii	10000	Allerod	Warmer	Birch + Park Tundra
LATE DEVENSIAN i	i	11000	Lower Dryas	Cold	Park Tundra

table.2

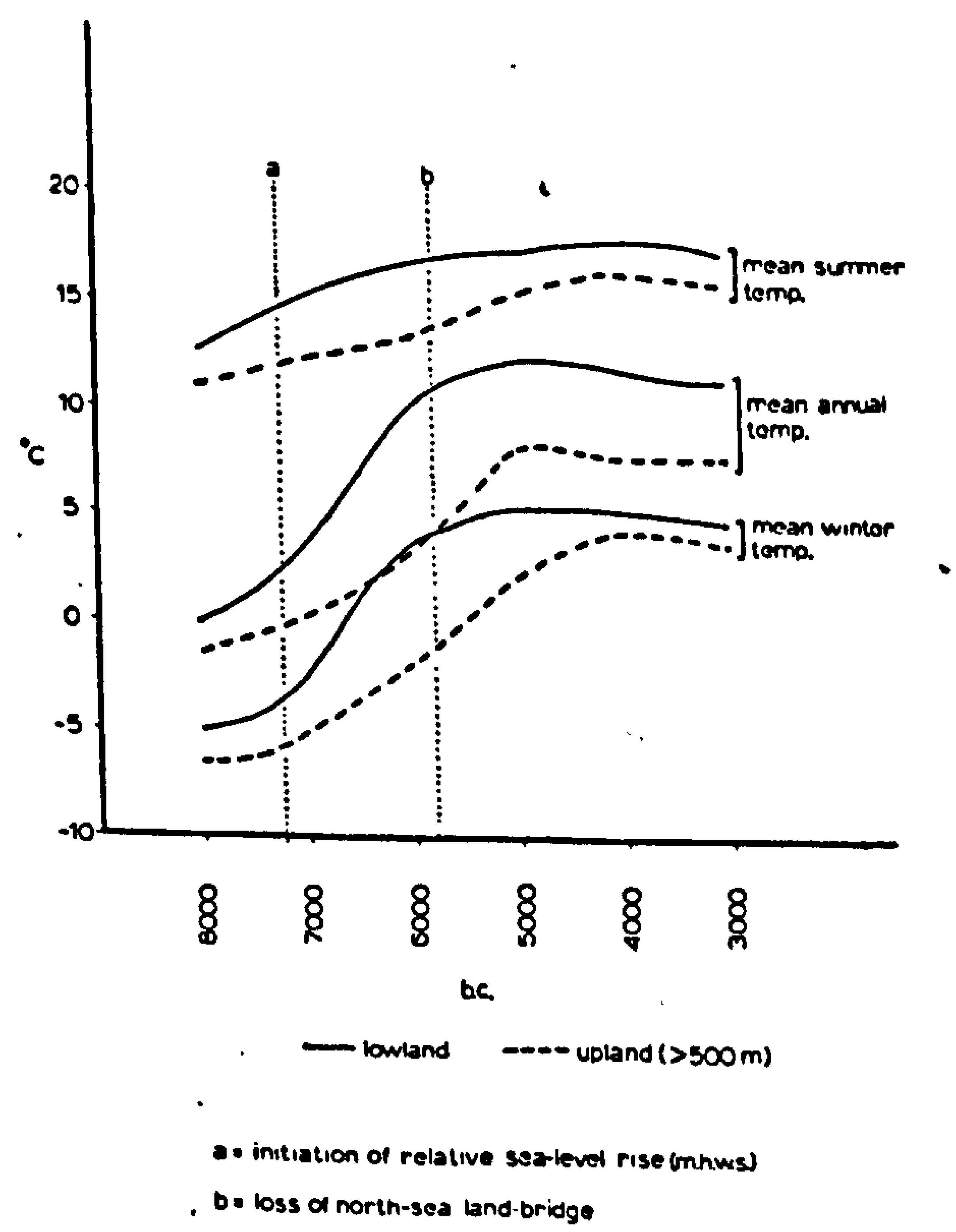


fig.13

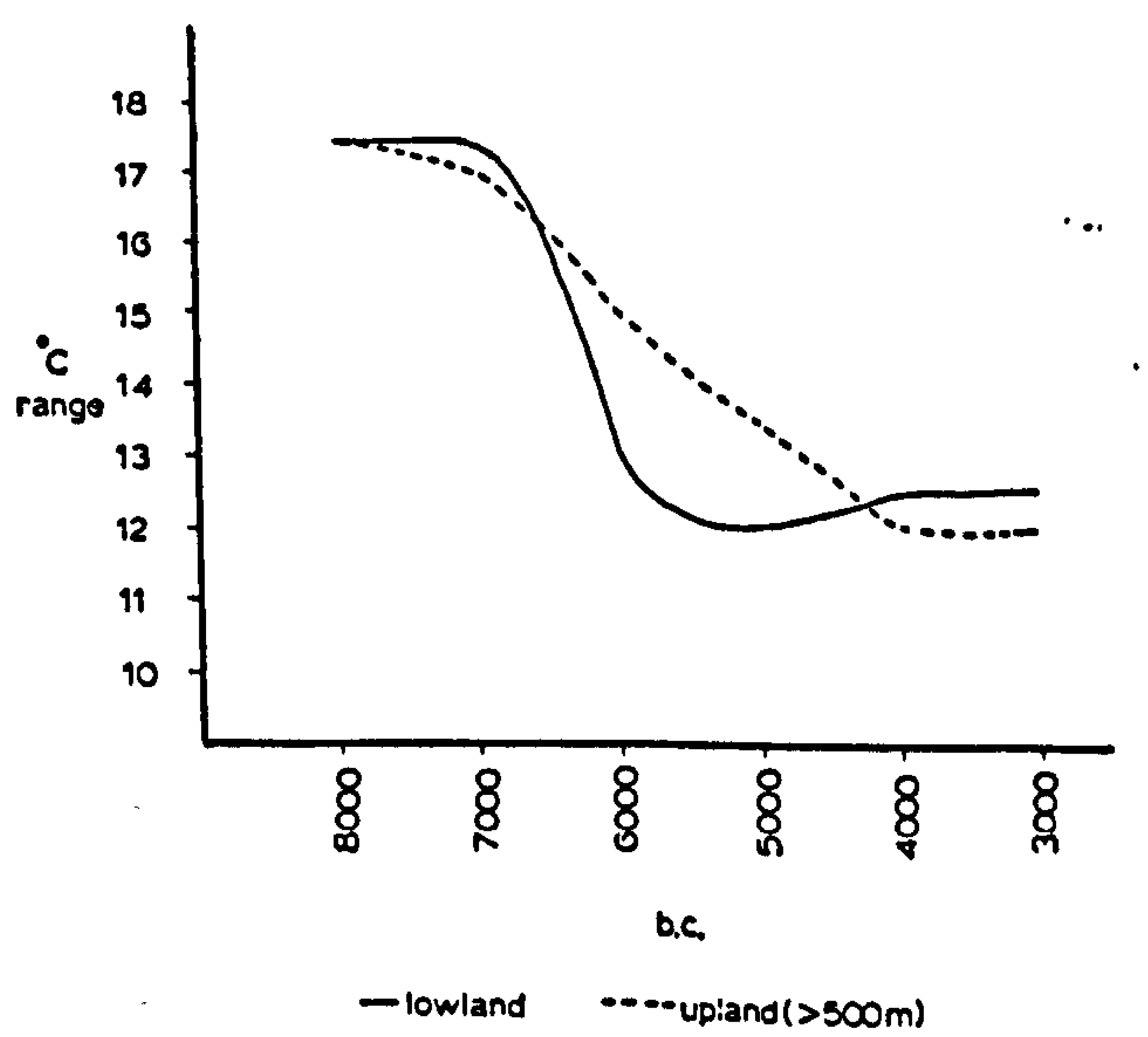


fig.14

amelioration (see also Simmons et al. 1981: 91). The ameliorating influence of rising sea-levels and increasing oceanicity as Britain was physically surrounded by water will have been more rapidly felt in lower lying areas.

In general, therefore, the pattern of temperature change provided by Taylor conforms with the picture subscribed to by Lamb et al. (1966) of short summers prior to 6000 b.c. with the rest of the year being very cold, and a more ameliorated, oceanic climate after 6000 b.c.. If we look at Taylor's estimates more closely, and examine the changes in mean temperature ranges (mean winter/mean summer) we can see (fig. 14) that in the lowland temperature ranges remain at approximately 17.5°C between 8000 b.c. and 7000 b.c.. Between 7000 b.c. and 6000 b.c., however, temperature ranges drop dramatically to approximately 13°C, whereafter they stabilize at 12°C to 12.5°C. The suggestion here is that between about 7000 b.c. and 6000 b.c. those areas of Britain below 500 metres experienced a decline in the range of mean summer to mean winter temperatures of some 4.5°C. Allowing for the fact that these are estimates of average temperatures an overall reduction of 4.5°C in the range would appear to represent a dramatic contribution to the amelioration of annual temperatures.

Whilst discussions of the nature of post-glacial climatic and, in particular, temperature regime changes have normally focussed attention upon the absolute temperature, the temperature range may, in certain respects, prove a more informative element when considering the relationships between climate and the behaviour of specific resources in the environment. For example, for many animal species migration serves as an adaptive measure in seeking to optimize reproductive fitness. In many instances, migrations are initiated by the onset of adverse conditions whereupon a species will relocate according to the distribution of more favourable conditions.

To some degree the regularity and severity of adverse conditions will, in turn, influence the degree of consistency and regularity of migratory responses. As discussed in the previous chapter, migrations amongst target resources provide time-stressed hunter-gatherers with the opportunity for both minimizing risk and maximizing time in the performance of subsistence procurement. Such a perspective may prove to be of interpretative value in the discussion of Mesolithic adaptations and will be examined in more detail at a later stage. The essential point here is that the temperature range may play an important role in the assessment of the characteristics of resource migrations.

In summary, the climate of early post-glacial Britain appears to have undergone a significant change at or about 5800 b.c.. Prior to this time Britain was subject to a 'continental' temperature regime with short, but possibly hot summers. After this time Britain's climate was increasingly influenced by the ameliorating effects of insularity, becoming 'oceanic' in character. It was during this latter period that winter temperatures reached and sustained an average 2^{o}C above those of the present day, with the autumn and spring seasons probably extended (Simmons et al. 1981: 89). The increasingly oceanic characteristics probably were associated with increasingly windy conditions and greater levels of precipitation. Lamb et al. (1966) have suggested that in the earlier, more continental, conditions annual precipitation was 92 - 95% of present averages, whereas during the later, more oceanic conditions rainfall increased (Simmons et al. 1981: 90).

3) Vegetation

Studies of the development of post-glacial floral communities in Britain have, over the years, benefited from detailed analyses of both macroscopic and microscopic evidence of plant remains. An increasingly detailed picture of the vegetational succession which followed the end of the last glaciation has, as a result, developed. The study of fossil pollen records preserved in peat bogs, former lake-beds and other, similar deposits has, in particular, contributed greatly towards our ability to reconstruct and discuss the compositional changes in Britain's early post-glacial vegetation.

Following on from early work in the field (Erdtmann 1928, 1943; Jessen 1949) the important programme of pollen analysis pursued by Godwin (1940a, 1940b, 1941, 1948) and others (Godwin and Tallantire 1951; Godwin et al. 1957) saw the establishment of a pollen zonation scheme (Godwin 1940a) for post-glacial Britain. Subsequently, major syntheses of British vegetational history were published (Godwin 1956; Pennington 1969). The previously mentioned work of Hibbert et al. (1971) at Red Moss, Lancashire saw the application of absolute dating techniques to a complete pollen stratigraphical record for the Flandrian and the establishment of six chronozones based upon changes in pollen assemblages. A summary of the schemes developed by Godwin (1940a) and Hibbert et al. (1971) is presented in table 2. Whilst it can be seen that there is a broad degree of correspondence between these schemes it should be emphasized that as the results of further analyses using absolute dating techniques have become available (Hibbert and Switsur 1976; Godwin et al. 1957; Williams 1985) variations in both the timing and nature of vegetational changes at a regional level have become increasingly apparent.

At the end of the Devensian glacial period the intense cold had given rise to a largely treeless, open tundra vegetation consisting of herbaceous plants, grasses, sedges and dwarf tree forms of birch and arctic willow (Morrison 1980: 93; Simmons et al. 1981: 94). One of the most striking characteristics, therefore, of the transition from late-glacial to early post-glacial vegetational patterns (zone III - IV boundary, using Godwin's 1940a scheme) was the rapid rise in the frequency of arboreal pollen, particularly that deriving from tree birches.

At Din Moss (Hibbert and Switsur 1976), close to the Northumberland-Roxburghshire border, the transition from late Devensian to early post-glacial vegetation patterns is reflected in the rise of Betula pollen, associated with low levels of Pinus. Characteristically, this period also shows a high value for Juniperus. A date of 8390 ±200 b.c. (Q - 1078) for the transition can be compared with dates marking the same transition at Tregaron and Nant Francon (Hibbert and Switsur 1976) of 8250 ±220 b.c. (Q - 930) and 8130 ±220 b.c. (Q - 890) respectively. Although the dates for the same transition at Red Moss (Hibbert et al. 1971) are suspect it is interesting that in all four cases herbaceous pollen remains a major component to the pollen rain. Whilst the appearance of tree birch pollen and other, less well represented tree species at or shortly after 8300 b.c. has been taken as reflecting the establishment of forest (Mellars 1974: 77) we cannot be certain, initially at least, as to the stature of such trees (Simmons et al. 1981: 94). It seems probably that the process of afforestation was accompanied, in the earlier stages, by the persistence of open areas with herbaceous growth and stunted tree birches. As discussed earlier, it may well be that this process was more rapid in certain regions of southern England, but that the establishment of forest cover was achieved in northern England during the first half of the eighth millenium b.c..

The zone IV forest cover appears to have varied in composition, with birch dominating tree pollen spectra in the north, and pine making an increasingly important contribution in some regions of the south as shown in the spectra from Hockham Mere, Norfolk (Godwin and Tallantire 1951). The transition to zone V is characterized by the first continuous representation of hazel pollen and, in many regions, its rapid rise in percentage contribution. Dates for this transition in northern regions appear to be relatively consistent (Hibbert and Switsur 1976: 801), at or around 7800 b.c.. Late in zone V and into zone VI hazel pollen values, in many cases, rise to over eighty percent of arboreal pollen. At Tregaron, where the rise of hazel pollen is associated with the first continuous representation of oak and elm, the increase in hazel pollen values is dated to 7350 ±190 b.c. (Q - 933), whilst at Nant Francon the same general trend is dated to 6980 ±170 b.c. (Q - 895). Explanations for the dramatic and widespread rise in hazel values during zone VI have particular implications for the discussion of the activities of human groups at that time and will be discussed in more detail later. In general, however, the rise in hazel corresponds with declining values for birch and, in some regions, increases in the representation of oak, elm and, late in zone VI, lime. The establishment of a variety of thermophilous tree species during zone VI may be a reflection of the increasingly ameliorated conditions with less severe winters being experienced, and of the progressive development of suitable soil conditions.

The transition from zone VI to zone VIIa, however, does appear to be characterized by pollen spectra changes which reflect the increasing influence of warmer, moister and more oceanic conditions mid-way through the sixth millenium b.c.. Zone VIIa is characterized by the establishment of 'mixed-oak forest' including oak, elm, lime and alder. Once again, the timing and precise character of the vegetational changes associated with the transition from zone VI to zone VIIa vary between regions, according to regional and local variability in a host of topographical, pedological and climatic factors. At Tregaron and Din Moss (Hibbert and Switsur 1976) the first continuous representation and subsequent rapid rise of <u>Alnus</u> has been dated to 5040 ±180 b.c. (Q - 937) and 5200 ±120 b.c. (Q - 1070) respectively whilst at Nant Francon <u>Alnus</u> had been present, in low numbers, since before 6500 ±150 b.c. (Q - 898). Interestingly, however, alder values at Nant Francon increase rapidly after 4930 ±110 b.c. (Q - 900), roughly contemporary with the similar increases noted for Tregaron and Din Moss, possibly reflecting increasingly moist conditions (but see Simmons et al. 1981: 99). In general, however, the period prior to 5500 b.c. saw the steady replacement of birch and pine with a diverse mixed deciduous cover. Hazel persisted throughout, though not at the high levels of abundance recorded in zone VI. Additional species, such as holly, ivy and ash are also characteristic of the forest cover after 5500 b.c..

In comparison with the sequence of vegetational development prior to 5500 b.c. the pollen record for zone VIIa, between 5500 b.c. and approximately 3200 b.c., appears to reflect only relatively minor compositional adjustments. This general pattern has led Simmons et al. (1981: 94) to characterize the earlier period as one of change and the later period as one of relative stability. The general developmental picture presented here does little, however, to inform us about synchronous variability in forest composition across regions. Recent approaches employing multivariate discriminatory techniques on regional pollen data sets (Turner and Hodgson 1979, 1983) have indicated possible correlations between aspects of species composition and other environmental variables, such as altitude and parent geology, in early and mid-Flandrian forests. Such approaches are, however, restricted by the relative scarcity of studies of pollen sequences that have associated absolute dates upon which discussions of synchronous variability in regional vegetation patterns might be independently established.

4) Anthropogenic influences upon vegetation

Until relatively recently it was widely assumed by palaeoenvironmentalists and archaeologists alike that prehistoric hunter-gatherers were neither technologically capable nor behaviourally inclined towards activities that would yield anything but the most localized and short-term influences upon vegetational patterns. Over the past twenty years, however, increasing attention has been given to the possible role of anthropogenic agencies in influencing vegetational development during pre-farming contexts in Britain. The significance of this change in perspective lies not so much in the acceptance that the activities of Mesolithic hunter-gatherers may have indirectly given rise to alterations in vegetational sequences but rather in the awareness that such groups may have deliberately sought to modify vegetation as an integral part of their economic strategies. It is in this latter perspective of Mesolithic behaviour that we see the departure from the more traditional views, as expressed by Godwin (1965), of such groups being,

> 'one component of the ecosystem, dependent upon the forest, rivers and lakes for food, surrounded and dominated by the forest.'
>
> (Quoted in Simmons 1969b: 111).

The change in perspective with regards to the capacity of hunter-gatherers to purposefully manipulate their environment has been part of the broader realization of the degree of knowledge, planning and control over subsistence activities exhibited by hunter-gatherers. Far from being the largely passive, opportunistic societies depicted in more traditional accounts (Cornwall 1968) it is now clear that many hunter-gatherer societies employ a detailed knowledge of the spatial and temporal behaviour of resources in planning and undertaking subsistence activities (see previous chapter). It is against this background of changing attitudes that evidence for the deliberate modification of vegetation by hunter-gatherers has contributed to recent thinking concerning certain characteristics of the vegetational record of early post-glacial Britain.

The evidence for manipulation of vegetation by Mesolithic groups in Britain takes a variety of forms, but is primarily concerned with the possible effects upon vegetation and soil development of forest clearance activity. The term 'clearance' used here does not, of itself, imply any specific mechanism of clearance but rather refers to the reduction of tree cover and the creation of clearings in a forest environment. One of the most important sources of evidence for clearance activity has come from pollen analyses. As outlined previously, the general trend of vegetational development during the Mesolithic is one of developing forest cover. In general, as the processes of forest closure and development proceeded the pollen record shows a reduced representation of light demanding ruderals and grasses in response to the reduced availability of light under the forest canopy (Simmons et al. 1981: 104). The reappearance of such low growing, light demanding species in pollen analyses represents, therefore, a non-conformity in the trend of increasing forest cover.

Similarly, evidence for the recession of forest cover and the replacement of arboreal pollen indicators by indicators of open ground presents us with a vegetational change against the overall expectations of forest closure (Simmons 1979: 114). In some instances pollen evidence for forest clearance may be associated with evidence for soil disturbance or erosion providing further indications of the effects of clearance activity (Simmons 1979: 114).

Finally, pollen evidence for clearance and/or the erosion of soils may correspond with physical evidence for the mechanism of clearance. Most notably, the association of such clearance evidence with macro or microscopic charcoal fragments might be taken as evidence for the creation of clearings by fire. Clearly, however, the presence of evidence for fire-created clearances in early post-glacial forests need not, of itself, imply the deliberate participation of man in the creation of such clearances. In order that we may distinguish between the creation of clearings by natural, non-anthropogenic agencies and the deliberate manipulation of vegetation by man alternative lines of evidence and reasoning must be sought.

5) Evidence for clearance during the Mesolithic

A number of authors have suggested that the remarkably high percentages of hazel pollen noted for the Boreal and late Boreal periods may have been the product of deliberate burning activity by Mesolithic groups (Mellars 1976b: 31; Simmons 1979: 114; Smith 1970: 82-3). Being a species resilient to all but the most intense of fires hazel, it is argued, may have selectively benefited from the reduction of competing vegetation and rapidly regenerated to achieve dominance. In view of the use of hazel nuts as a food resource during the Mesolithic (Jacobi 1978b; Mellars 1976a) it is suggested that such fires may have been deliberately set in order to encourage this useful resource.

Certainly, the ethnographic record provides examples of hunter-gatherers burning vegetation as a means of promoting the growth of desired plant resources (Lewis 1973: 66; Stewart 1956: 120). There are, however, two problems associated with the hazel increase which need consideration. First, such is the widespread and apparently synchronous nature of the hazel increase that doubts may be expressed as to the adequacy of a purely anthropogenic causal explanation (Morrison 1980: 112-13). Secondly, it has been recognized that any opening-up of the forest canopy would encourage species such as hazel, since it is a colonizing species, and, even if we accept man's participation in the creation of clearings, the increase in hazel may actually represent the abandonment phase of such activity (Williams 1985: 114).

However, recent years have seen a steady increase in palaeoenvironmental evidence for Mesolithic clearances associated with physical evidence for burning. In a study of Mesolithic occupation in the Southern Pennines Jacobi et al. (1976) recognized that despite clear evidence, in the form of preserved tree stumps, for the suitability of conditions above 350 m for tree growth, pollen evidence indicated that during zones VI and VIIa tree growth was suppressed over large areas above c. 350 m. Evidence for burning in the form of charcoal was also recognized in a series of peat and mineral soil profiles dating to zones VI and VIIa. In the light of this palaeoenvironmental evidence, and taken together with evidence for the contemporary concentration of Mesolithic sites between 350 m and 500 m it was concluded that the area witnessed repeated and regular clearance through burning by Mesolithic groups during zones VI and VIIa.

Similar evidence for extensive clearance activity has been reported from the North Pennines (Turner and Hodgson 1983), the North Yorkshire Moors (Simmons and Cundill 1974), and Dartmoor (Simmons 1964, 1969b). Evidence for repeated and prolonged clearance activities during zones VI and VIIa have been found in the Central Pennines (Williams 1985) and at Bonfield Gill Head, on the North Yorkshire Moors (Simmons and Innes 1981). Whilst evidence for clearance during the Mesolithic has come primarily from upland sites similar results have been reported from lower lying regions (Jones 1976). Whilst it is not certain that fire was the mechanism of clearance in all cases (Williams 1985: 118) the widespread association of pollen evidence for clearance with charcoal does suggest fire as a principal agency of clearance in many cases. Simmons (1969a), for example, reported pollen evidence for clearance at North Gill in association with a charcoal layer up to 5 cm thick. Subsequently, this burning layer was dated to 4416 ±69 b.c. (BM - 425) (Simmons 1975a: 2).

This evidence for clearance activity appears to correspond with the initiation of a progressive soil deterioration in areas of the British uplands. It appears that the base-poor parent material of such upland regions, once stripped of deep rooting trees and exposed to the leaching effects of rainfall was subject to progressive podsolisation and, in many cases, the formation of blanket bog. The correlation between upland forest clearance and the inception of blanket peat development has recently been emphasized (Moore 1975). The deterioration of upland soils during the Mesolithic is evidenced by the increased rates of silt deposition in upland valleys during zone VIIa (Smith 1982).

Whilst the bulk of the evidence for clearance comes from areas above 300 m in the northern and western areas of Britain there are certain interesting exceptions to this pattern. At the site of Iping Common, Sussex (Keef et al. 1965) pollen analysis revealed a late Boreal transition from a hazel woodland to heathland vegetation in association with evidence for burning. In this case, a Maglemosian type flint assemblage exhibited extensive signs of burning. Whilst it is clear that the assemblage must have been deposited at some point prior to the burning the association of vegetational changes, burning and man's presence has led to an interpretation of deliberate clearance activity by Mesolithic populations. Furthermore, the evidence from Iping Common and another Mesolithic site, Oakhanger (Rankine et al.1960), for a deterioration of soils following Mesolithic activity has been seen as comparable, in certain respects, to evidence for deterioration in upland sites (Simmons et al. 1981: 106-10). Both of these lowland sites occupy areas of light, sandy soils. Such soils, it is argued, would have been relatively base-poor and vulnerable to burning, with the fire destroying the soil structure allowing erosion to take place.

Not unreasonably, with the growing body of evidence for clearance during the Mesolithic period considerable research interest has developed into the possible role of such clearance activity, and particularly through the mechanism of burning, within a hunting and gathering economy (Jacobi et al. 1976; Mellars 1975, 1976b; Simmons 1969b, 1975a, 1975b, 1979; Smith 1970). Of the various discussions dealing with the potential benefits of clearance through deliberate burning to hunter-gatherer societies it is, perhaps, those provided by Mellars (1975, 1976b) that deal with the subject most comprehensively.

Taking advantage of the extensive literature concerned with the effects of controlled vegetational burning as part of modern forestry management Mellars (1975, 1976b) sought to identify those effects that would present adaptive benefits to hunter-gatherers. In very general terms the effects of interest can be divided into a) the benefits relating to the selective encouragement of plant food resources, and b) the benefits relating to the modification and control of animal resource behaviour.

Reference has already been made to the possible role of fire in the promotion of hazel growth. Mellars (1976b) recognizes that in many cases controlled burning of understorey vegetation can promote both an increase in the diversity of low growing vegetation and an increase in the net productivity of such growth. Increased diversity may give rise to the availability of more useful plant resources, whilst an increase in net productivity may serve to increase the quantity of such resources accessible to human populations. In addition to these benefits Mellars (1976b: 31) also notes that the removal of understorey vegetation might facilitate the ease and rate of collection for certain kinds of plant resources.

It is, however, with respect to the effects of fire upon forage production and the resulting implications for herbivorous animals and their exploitation by human groups that Mellars identifies the area of greatest potential for the role of fire. To summarize, the evidence of controlled burning experiments suggests that following such burns pronounced increases in forage production and the nutritional quality of forage are produced. These increases promote, in turn, increases in the density of herbivorous animal populations and increased rates of reproduction amongst such populations (Mellars 1975: 55, 1976b). In terms of hunter-gatherer exploitation strategies the capacity to purposefully modify vegetation in order to manipulate the distribution and availability of animal resource populations presents a series of implications.

As Mellars (1976b: 31-3) points out, the removal or reduction of understorey vegetation would present specific benefits in terms of mobility and hunting efficiency to hunter-gatherers exploiting animal resources in a forested environment. Where understorey vegetation is dense the task of locating game is made more difficult because of reduced visibility and impeded mobility. Furthermore, as discussed in the previous chapter, the capacity for game to avoid capture, even after being shot, where there is plenty of cover presents further demands upon their exploitation. Taken together, these problems associated with hunting in a forest environment with dense undergrowth serve to increase the time required for locating, pursuing and capturing resources. The reduction of undergrowth would, therefore, offer specific savings in time and energy whilst reducing the overall risks of failure to hunters living in such an environment.

Similarly, the capacity to encourage localized and predictable concentrations of animal resources would enable hunter-gatherers to reduce the investment of time and energy in locating and procuring resources. In certain respects, the promotion of increased animal population densities in specific locations would mimic the effects and implications for hunting strategies of regularized migrations amongst target resources (see previous chapter).

In the light of these considerations concerning the possible role of deliberate clearance activity amongst hunter-gatherers it is interesting to note that much of the evidence for clearance during the Mesolithic comes from areas where the manipulation of vegetation towards those conditions desired may have been somewhat easier than in other areas. Both with regards to the upland clearance evidence and the evidence from Iping Common and Oakhanger the base-poor soils in these areas may have enabled the effects of clearance to be prolonged. As noted by Simmons et al. (1981):

> 'here (the uplands) the ecosystems are in tension so that a small influence is likely to have a major effect on the dominant plant species.',

whilst,

> 'here (Iping Common) there was an environment rendered fragile by the poverty and instability of its soil.'
>
> (109).

In summary, therefore, there would appear to be a growing basis of palaeoenvironmental evidence indicating that during the Mesolithic period the trend towards afforestation was, in certain areas, interrupted by clearance. Whilst it is impossible to demonstrate conclusively that such evidence indicates clearance as a deliberate human strategy we now have a good theoretical understanding of some of the advantages that clearance would convey to hunting and gathering societies. Furthermore, the results of regional pollen analyses designed specifically to identify and examine in detail the clearance evidence (i.e. Willams 1985) appear to confirm, rather than reject, the likelihood that such clearances were increasingly an integral part of Mesolithic subsistence strategies. There remains, however, a number of questions concerning the precise purpose of such clearance activity, the chronology of clearance activity, and the techniques used in creating and maintaining such clearances (Williams 1985: 118). Whilst much of the evidence indicates clearances during the late Boreal, Atlantic periods (i.e. after c. 6000 b.c.) it must be remembered that not all pollen sequences extend back into the earlier periods (zones IV - V). It does, however, appear that if one accepts an anthropogenic explanation for much of the clearance evidence then the use of clearances was a widespread feature of Mesolithic behaviour after approximately 6000 b.c..

Although the precise function(s) of clearance during the Mesolithic may remain a debatable issue there can be little doubt that such clearances would have provided favourable hunting conditions within the forest environment. To what extent the behaviour of animal populations was deliberately modified is, once again, open to question. It is, however, interesting to consider the evidence for large concentrations of ivy pollen in certain Mesolithic sites (Simmons and Dimbleby 1974). In the absence of any reasonable, natural explanations for these concentrations it does seem feasible that they may have been the product of deliberate autumnal collection (when ivy flowers) for use as a winter fodder for herbivores such as red deer. The use of ivy as a fodder crop during prehistoric and historic periods has been discussed elsewhere (Troels-Smith 1960). In this light, it seems increasingly likely that Mesolithic groups may have sought to control or influence the distribution and availability of animal populations using a variety of techniques, including the production of clearances. Given these perspectives on Mesolithic behaviour it is becoming increasingly clear that the vegetational development of early post-glacial Britain can no longer be assumed to be the outcome of purely natural processes, and that the consideration of man as an agency of vegetational change will demand increasing attention.

6) Fauna

The transition from the late-glacial to the early post-glacial brought, as previously discussed, the relatively rapid replacement of open tundra conditions by an increasingly arboreal vegetation. Traditionally, the impact of these vegetational changes upon faunal populations has been regarded in terms of the replacement of late-glacial open-country forms - horse, reindeer, bison and mammoth - by species associated with woodland environments - red deer, roe deer, elk, aurochs and wild boar (Degerbøl 1964; Mellars 1974: 80). In terms of the implications for human exploitation, the transition from late-glacial to early post-glacial faunas has been seen as significant for two reasons:

> 'on the one hand the overall density of animal populations (the 'biomass') in forested areas is normally much less than ... in open tundra and grassland ...; on the other hand forest species ... tend to be less gregarious in their habits than open country forms .... In other words mesolithic communities had to adapt ... not only to a substantially reduced food supply but also to the pursuit of animals whose behaviour was significantly different from that of pre-existing glacial species.'
>
> (Mellars 1974: 80).

More recently, however, attention has been drawn to the comparative poverty in the diversity of animal species represented in Britain during the final, very cold stage of the Devensian (zone III) (Grigson 1978: 50; Simmons et al. 1981: 112). It has been suggested that the ungulate fauna of Britain during the Younger Dryas was largely confined to herds of horse and reindeer (Grigson 1978: 50) and lacked such animal species as bison, woolly rhinoceros, cave bear, cave lion, hyaena and giant deer (Simmons et al. 1981: 112).

As discussed in the introduction to this chapter, certain elements of the late-glacial fauna may have survived, beyond the conventional date for the onset of post-glacial conditions (c. 8300 b.c.), in certain regions of northern Britain. What is clear, however, is that the early post-glacial period saw a relatively rapid diversification of fauna as different species successfully colonized the developing post-glacial forests. The faunal evidence from the sites at Thatcham (King 1962) and Star Carr (Fraser and King 1954) clearly indicates the establishment of a diverse woodland, or woodland edge faunal community over much of lowland England by the middle of the eighth millenium b.c.. From this we might conclude that Mesolithic communities, in addition to having to adapt to a possible reduction in the biomass of animal populations and a range of species with behaviour patterns different from those of late-glacial species, were confronted with an increased diversity of species upon which to base their exploitation strategies.

Our understanding of the character of early post-glacial faunal communities is heavily constrained by the nature of the evidence available for us to examine. As far as vertebrate faunal samples go, almost all of the data derives from archaeological sites, and represents a 'culturally sieved' (Simmons et al. 1981: 111) sample of the then contemporary faunal populations. Secondly, and equally important, the restricted occurrence of conditions suitable to the preservation and survival of bones has imposed an additional bias upon our understanding of faunal populations. The majority of Mesolithic faunal samples derive from waterlogged, marsh-edge sites, or from shell-middens where good drainage and alkaline contexts combine to ensure faunal preservation. Consequently, our understanding of Mesolithic fauna may be highly biased towards the sorts of animal populations living in or around such marshy or coastal environments, at the expense of faunal communities in, for example, highland regions (E.E. Evans 1975).

Bearing in mind the contextual and cultural bias inherent in surviving Mesolithic faunal samples the picture available to us appears to indicate that, in terms of species representation, the vertebrate fauna of Mesolithic Britain established during the eighth millenium remained largely unchanged throughout the period (Grigson 1978; Simmons et at. 1981: 116). The major exception to this pattern is the possible extinction of the elk towards the end of the Boreal period. Reasons for the disappearance of the elk have been put forward and discussed (Grigson 1978: 54; Simmons et al. 1981: 116), and include both environmental and anthropogenic explanations. On the one hand it has been suggested (Grigson 1978: 54; Simmons et al. 1981: 116) that the drier, warmer climate of the late Boreal, combined with the development of increasingly dense pine forests, may have reduced the availability of habitats favoured by Elk. The same authors, however, also consider the possibility that Mesolithic groups may have hunted the Elk to extinction. Clearly, we cannot be certain as to the specific cause(s) of the disappearance of this species. The probability that a combination of factors, environmental and anthropogenic, brought about the Elk's demise would appear to represent the compromise between the two explanations.

That the evidence for vertebrate species representation during the Mesolithic indicates, with the exception of Elk, relatively little change through time is, perhaps, not so very surprising. The progressive insularization of the British mainland, and the final severance from the continent after 5800 b.c., effectively stopped the influx of new ungulate and other terrestrial species. Although the faunal data-base for the Atlantic period expands to include a wide range of coastal species of birds, fish, seals, whales and molluscs such changes reflect the increased representation of coastal archaeological sites and not, necessarily, any alteration in the faunal communities.

Whilst the range of species present in faunal communities may have remained largely unchanged throughout the Mesolithic period this does not imply that the numerical, spatial and behavioural characteristics of animal species remained unaltered. We know, for example, that the ameliorated conditions of the Atlantic period were associated with northerly extensions of molluscan populations of 'southern species' (*sensu* Lewis 1964: 234) as evidenced by their presence in estuarine clays and raised beaches of north-east Ireland (Praeger 1888, 1896).

Similarly, the presence of substantial populations of another southern species of mollusc, Monodonta lineata (Da Costa), in the Mesolithic shell-midden of Culver Well, Portland (Palmer 1977; Myers 1978), indicates the effects of warm air temperatures during the Atlantic upon a species whose current distribution along the south coast of England (Hawthorne 1964; Crisp and Southward 1958) reflects its vulnerability to the sudden onset of cold air temperatures (Desai 1966).

Whereas it is possible to discuss, with some conviction, the effects of the progressive climatic amelioration during the early post-glacial period upon certain temperature sensitive molluscan species the situation with regards to ungulate behaviour is far more complex and problematic. The responses of ungulate populations to changes in habitat involve considerations of a wide range of environmental variables, including topography, drainage, vegetation, wind patterns, and temperature regimes - to name but a few. It may, however, prove useful to consider some of the implications of the general trends in climate and vegetation observed for the Mesolithic period for one important aspect of ungulate behaviour - migration.

The study of animal migration as a specialized behaviour distinguishes between systematic and intentional movement, on the one hand, and accidental or unsystematic movement on the other (Dingle 1980: 5). In this way, migration can be regarded as a strategic response upon which natural selection may operate, and not simply as a mechanistic response characteristic of particular species. In viewing migration as a strategic option it is possible to consider the adaptive benefits of movement, in a given context, against the benefits of non-migratory responses. From this it follows that, 'Ultimately selection acting on migration is a function of the relative survival and subsequent reproductive success of migrant and non-migrant individuals.'

(Dingle 1980: 78).

It is not surprising, therefore, that in all but the most extreme cases of resource based migration (i.e. the movements of northern cervids) large terrestrial mammals tend to exhibit mixed strategies with portions of the population migrating and others remaining relatively sedentary. In this light it is understandable that studies of the spatial and temporal behaviour of, for example, red deer (Ahlén 1965; Clutton-Brock and Harvey 1978; Clutton-Brock et al. 1982; Dzieciolowski 1979; Staines 1977) in differing habitats, whilst providing a generally clear picture of the summer dispersal and winter 'yarding' behaviour, also illustrate the varied degree and spatial extent of such responses. Similarly, Prior (1968) recognized that the tendency for roe deer on Cranborne Chase to remain within relatively small, defined areas was attributable to mild climate and abundant feeding habitat throughout the year (31). Where winter feeding was limited Prior noted that larger numbers would aggregate in the suitable areas (32). Whilst it is clear that the behaviour of red and roe deer differs in that red deer tend to aggregate in herds during winter, and roe deer tend to remain in relatively small groups the degree of aggregation and movement is, in both species, responsive to local conditions.

Returning to the post-glacial, it is a matter of speculation to suggest that the migratory responses of different ungulate species may have changed in specified ways as climate and vegetation changed. The factors that influence the timing, regularity, extent and level of participation are variable both within and between species. There are, however, certain generalized aspects of the climatic and vegetational developmental sequence outlined previously that may have some bearing on animal migration.

Climatically, the principal trends in temperature regimes involved a rise in average temperatures, a reduction in seasonal temperature ranges, and a shortening of the winter season through extensions of the autumnal and spring seasons. These changes appear to have proceeded most rapidly between approximately 7000 b.c. and 6000 b.c.. If, as previously discussed, the migratory responses of ungulates can be regarded as adjustments to the onset of adverse conditions then the climatic changes noted above may have had specific implications for the timing, regularity and extent of such responses. The rise in average temperatures, associated with less severe winters may have served to provide a selective advantage for more sedentary responses at the expense of migration. In addition, the extension of the autumnal and spring seasons may have served to introduce greater variability in the actual timing of migratory responses.

In terms of vegetation, of course, it is primarily the availability of suitable food supplies for forage or browse that will have influenced the responses of ungulates at the onset of winter. It seems likely that in comparison with the closed Boreal pine forests the development of mixed deciduous woodland would have seen a marked increase in understory vegetation. If this is generally correct then the period between the Boreal and the establishment of the Atlantic woodlands may have witnessed vegetational changes which favoured ungulate populations, and may have promoted less mobile strategies through the increased availability of food.

Taken together, the trends in climate and vegetation during the period between 7000 b.c. and 5500 b.c. may have seen the progressive reduction of the adaptive benefits of migration in favour of more sedentary responses. Of course, it is impossible to confidently state the consistency in timing, regularity and extent of migrations for individual species prior to 7000 b.c.. What may be suggested, however, is that in comparison with the situation pre. 7000 b.c. the period between 7000 b.c. and 5500 b.c. may have seen reductions in the regularity of the onset of migrations, in the spatial organization of migrations, and in the overall level of migrations.

In conclusion, therefore, whilst the available faunal evidence may only permit us to say with confidence that the range of faunal species established by the mid-eighth millenium remained largely unchanged there may have been a series of modifications in the characteristics of movement for certain ungulates associated with the climatic and vegetational developments between approximately 7000 b.c. and 5500 b.c.. The implications of such modifications in the behaviour of ungulates for human exploitation patterns will be considered later.

Mesolithic chronology and typology: England and Wales

Following the early work of Clark (1932) it has been generally recognized that, typologically, the stone tool inventories of Mesolithic sites on the British mainland exhibit considerable variability. Prior to the advent of absolute dating techniques, and in the virtual absence of stratified lithic industries, the provision of a chronological framework within which the typological variability of Mesolithic tool forms could be sequentially organized was largely dependent upon stylistic comparisons with continental assemblages (Clark 1955, 1958).

More recently, however, the growing numbers of absolute dates associated with Mesolithic industries has provided the basis for an increasingly detailed chronological framework within which to examine changes in the lithic industries of the period. Utilizing the available radiocarbon, pollen and limited stratigraphical evidence it was initially suggested (Jacobi 1973; Mellars 1974) that, typologically, Mesolithic stone tool industries could be chronologically sub-divided into two general periods or phases. Industries belonging to the 'Earlier Mesolithic', it was argued, belonged, chronologically, to the period between the end of the last glaciation (c. 8300 b.c.) and the middle of the seventh millenium b.c., when they are replaced by industries of the 'Later Mesolithic'.

Earlier Mesolithic industries were characterized as containing a restricted range of 'non-geometric' microlithic forms including large, obliquely blunted points and trapezoids, as well as a range of distinctive non-microlithic tool forms including transversely sharpened axes, steeply backed 'awls', end-scrapers and burins. Later Mesolithic industries, on the other hand, were characterized by the replacement of earlier microlithic types with a wide range of smaller, 'geometric' shapes of microlith including scalene triangles, rhomboids, Mesolithic chronology & industrial association: England & Wales

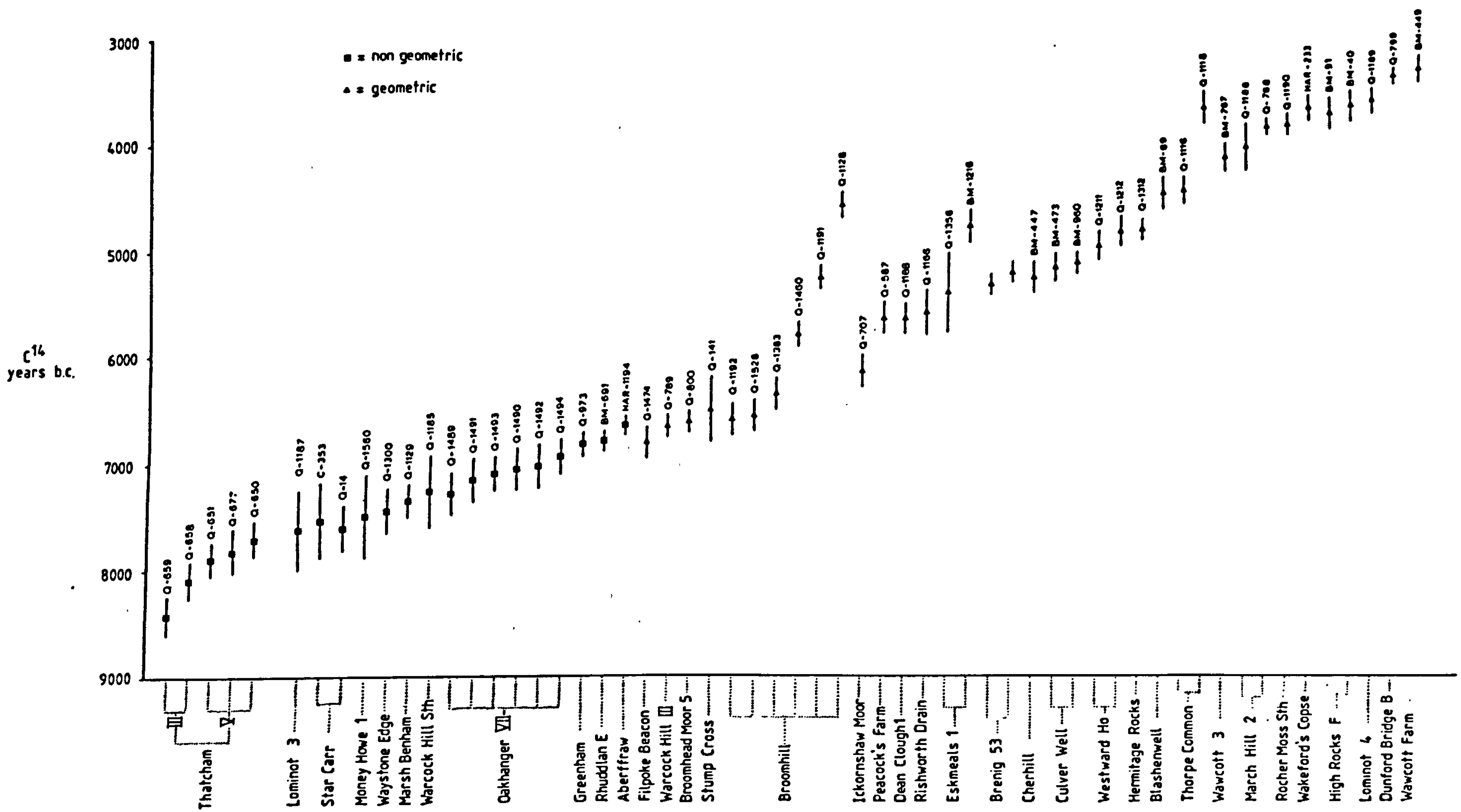


fig.15

rectangles, rod-forms and micro-crescents (Mellars 1974: 87).

At the time when this chronological/typological partitioning of the Mesolithic was suggested certain anomalies to the overall pattern were identified and, although subsequent excavations and further radiocarbon dates (Switsur and Jacobi 1975) have tended to confirm the general framework of an earlier and later Mesolithic, some of these problems remain. One of the most serious anomalies which has been resolved concerned the dating evidence for the very large industry from Oakhanger VII (Rankine 1952a; Rankine and Dimbleby 1960). Two radiocarbon determinations from phases 1 and 2 of this site produced dates of 4435 ±110 b.c. (F - 67) and 4430 ±115 b.c. (F - 68) respectively, placing an industry that otherwise would fit into the earlier period well into the fifth millenium b.c.. Recognition of this anomaly, and the fact that the samples used for these dates were untreated and suspected of having been contaminated (Jacobi 1973: 238) led to the subsequent submission of further samples from secure contexts in the site for dating. The resulting six radiocarbon dates now provide a date range for phase 2 of 7275 ±200 b.c. (Q - 1489) to 6935 ±165 b.c. (Q - 1494) confirming the Earlier Mesolithic status of the industry, and further confirming the anomalous character of the two fifth millenium b.c. dates (Jacobi 1976: 67). The experience of the effect which anomalous dates and industrial associations may exert over chronological frameworks, as with the case of Oakhanger VII, must be borne in mind as will be discussed subsequently.

The expanding list of secure radiocarbon determinations for Mesolithic industries in England and Wales (fig. 15; Appendix 1) now provides us with a clearer picture of the chronological relationship between earlier 'non-geometric' and later 'geometric' industries. It can be seen (fig. 15) that, in general terms, the Earlier Mesolithic has, in southern England, the earliest recorded dates from sites III and V at Thatcham (Churchill 1962; Wymer 1962), ranging from 8415 ±117 b.c. (Q - 659) at site III, to 7720 ±160 b.c. (Q - 650) at site V. A further date (not shown) from site II of 6140 ±180 b.c. (Q - 652) is suspected of contamination. The later, accepted dates from Thatcham are broadly contemporary with the earliest recorded dates for Mesolithic industries in the north of England: 7610 ±370 b.c. (Q - 1187) for Lominot 3, 7607 ±210 b.c. (Q - 14) and 7538 ±350 b.c. (C - 353) for Star Carr, 7480 ±390 b.c. (Q - 1560) for Money Howe 1, 7446 ±210 b.c. (Q - 1300)for Waystone Edge. Whilst it is possible that future work may produce late ninth millenium b.c. dates for Mesolithic industries in northern England, thereby corresponding with the earliest dates from Thatcham, a number of points suggest that the 'discrepancy' in evidence for earliest Mesolithic activity between northern and southern England does, in fact, reflect a chronologically delayed appearance in the north.

In the introduction to this chapter attention was drawn to evidence which suggests that more open, late-glacial environmental conditions may have persisted into the eighth millenium b.c. in northern England and that late-glacial type technologies, as indicated from Anston Cave, South Yorkshire, may have remained in use up until their replacement by Earlier Mesolithic industries (Jacobi 1978a: 299). We might also note that if the apparent discrepancy between the earliest Mesolithic dates in southern and northern England is simply due to problems of sampling then it would seem unusual that the north has produced such a concentration of radiocarbon dates for the middle of the eighth millenium b.c..

In contrast with the increasing certainty with which we can discuss the earliest appearance of Mesolithic industries in England the situation for Wales is far less clear. Dates of 6789 ±86 b.c. (BM - 691) for Rhuddlan E, 6598 ±73 b.c. (BM - 882) for Rhuddlan M, and

6690 ±150 b.c. (Q - 1385) and 6640 ±90 b.c. (HAR - 1194) for Aberffraw place Earlier-type industries relatively late in comparison with the latest dates for Earlier Mesolithic industries in England (see fig. 15: BM - 882 and Q - 1385 not shown). Given the limited number of dates presently available it appears that until further determinations are forthcoming any discussion of the earliest occurrence of Mesolithic industries in Wales must remain speculative in nature.

From the middle of the eighth millenium b.c., therefore, we have evidence for Earlier Mesolithic industries over much of northern and southern England, both in low lying and in more elevated locations. The traditional view of early settlement being confined to the south and eastern lowlands no longer appears accurate. Evidence for earlier Mesolithic findspots in the south-west has steadily increased (Jacobi 1979a; Wainwright 1960), as has evidence from the Cheshire plain (Cane and Higham 1984).

1) <u>Earlier - Later Mesolithic transition</u>

Our understanding of the chronology of the replacement of Earlier industries by characteristically Later assemblages is geographically uneven. In the north of England the latest date for an Earlier industry comes from the Wetton Mill rockshelter (Kelly 1976) where a date of 6897 ±210 b.c. (Q - 1127) (not shown in fig. 15) associates an early industry with a fauna of red deer and wild pig, as well as elements of a relict late-glacial fauna (arctic fox, arctic hare, wolverine). The date of 6829 ±110 b.c. (Q - 973) from Greenham Dairy Farm (Sheridan et al. 1963) provides us with a contemporary date for the latest known occurrence of an Earlier Mesolithic type industry in southern England. However, despite the broad correspondence between these dates, the dating evidence for later industries is less evenly distributed. The site at Filpoke Beacon, Durham, (Coupland 1948) has provided a date, on broken nut-shells associated with an industry dominated by narrow 'rod-like' and scalene microliths, of 6810 ±140 b.c. (Q - 1474) thereby giving us the earliest determination for an assemblage of Later Mesolithic character (Jacobi 1976: 71) in mainland Britain.

Other dates for northern assemblages of Later-type - 6660 ±110 b.c. (Q - 789) for Warcock Hill 3, 6623 ±110 b.c. (Q - 800) for Broomhead 5 - appear to confirm that in northern England Earlier Mesolithic industries were replaced by Later-types during the first half of the seventh millenium b.c.. For southern England, only the site of Broomhill, Braishfield (O'Malley 1976, 1978; O'Malley and Jacobi 1978) has produced dates clearly associating a Later-type industry with the first half of the seventh millenium b.c.: 6590 ±150 b.c. (Q - 1192), 6565 ±150 b.c. (Q - 1528) and 6365 ±150 b.c. (Q - 1383). Indeed, apart from the Broomhill dates there are no radiocarbon determinations for Later Mesolithic industries whose means fall in the seventh millenium b.c..

This gap in our radiocarbon chronology is particularly significant since it is in the area of the Weald and Hampshire that the existence of a possible further typological/chronological sub-division of Mesolithic industries may exist (Jacobi 1981) . It has long been recognized (Clark 1932: 104; Clark and Rankine 1939; Woodcock 1973) that certain Mesolithic industries contained obliquely blunted points, large numbers of isosceles triangles, rhombic microliths and distinctive concave basally retouched points including the asymmetric 'Horsham Point' (Rankine 1953 fig. 3 No. X). Such industries, apparently combining Earlier and Later microlithic traditions are concentrated within the Weald (Jacobi 1981 : 12), and may represent an intermediary development between Earlier and later industries (Jacobi op. cit.:13, 1978c). The existence of such industries at sites like Selmeston (Clark 1934a), Farnham (Clark and Rankine 1939), and Abinger Common (Leakey 1951) has encouraged some authors (Clark and Rankine 1939; Woodcock

1973) to refer to the existence of a 'Horsham' culture, but until our chronological understanding of these Wealden industries improves their position in the Mesolithic will remain uncertain.

The chronology of the transition from Earlier to Later Mesolithic industries in Wales is, at present, a matter of speculation. As previously noted, the dates for Earlier industries fall late in comparison with the latest dates for Earlier-type industries in England, perhaps indicating their persistence in Wales beyond the time of their disappearance in England. The only secure dates for Later-type assemblages in Wales come from the excavations at Brenig (Musson 1975) where dates of 5240 ±100 b.c. and 5350 ±100 b.c. were obtained from pit 19 at Brenig 53 in association with flint flakes and one scalene triangle. A larger assemblage of Later Mesolithic type at Brenig 40 cannot be directly associated with the date of 5700 ±80 b.c. (HAR - 656) from a context underlying a Bronze Age cairn (Lynch and Allen 1975). Consequently, we have no secure chronological evidence for the existence of Later industries in the region prior to the latter half of the sixth millenium b.c.. Furthermore, the date of 4010 ±120 b.c. (Q - 530) on peat associated with the lithic industry at Freshwater West (Wainwright 1959), whilst clearly dating the peat to the Mesolithic period, may not actually reflect the age of the industry whose Mesolithic status has been seriously doubted (Jacobi 1980b: 178; R. Jacobi pers. comm.). Once again, the radiocarbon evidence from Wales is so limited that, for the present, our understanding of the chronology of Later Mesolithic industries is confined largely to the observation that we have evidence for their presence during the latter half of the sixth millenium b.c..

In summary, the available radiocarbon evidence suggests that in northern England the replacement of Earlier industries by Later technologies may have begun as early as the first quarter of the seventh millenium b.c..

Allowing for standard deviations it is clear that by the middle of the seventh millenium b.c. Later Mesolithic industries were established throughout the north of England. In the south, however, the picture is less certain although the mid-seventh millenium b.c. dates from Broomhill might suggest the establishment of Later industries at that time. For Wales, the limited chronological evidence enables us to say little of value except that there may be some indication for the survival of Earlier technologies into the middle of the seventh millenium b.c., broadly contemporary with a series of dates for Later industries in the Pennine district (Warcock Hill 3, Broomhead 5: see fig. 15) and later than the date from Filpoke Beacon.

2) Duration of Later Mesolithic

Our understanding of the chronological duration of the Later Mesolithic period is dependent not only upon the available radiocarbon evidence for Later industries, but also upon our understanding of both the chronology and mechanisms associated with the establishment of 'Neolithic' economies and technologies. Traditionally, the advent of the Neolithic period has been associated with the widespread, dramatic evidence for declining pollen values for lime - frequently assumed to represent the environmental impact of farming economies - mid-way through the fourth millenium b.c.. More recently, however, the debate over the significance of the elm decline (see Smith et al. 1981: 134-36) has encouraged a renewed examination of the archaeological evidence for the transition from later Mesolithic to Early Neolithic adaptations (Bradley 1984; Jacobi 1982; Whittle 1977).

Radiocarbon evidence for Later Mesolithic industries, once subject to critical examination, reveals considerable variability in the latest reliable dates between regions. In northern England a series of determinations place Later industries in the first half of the fourth millenium b.c.. Dates of 3730 ±150 b.c. (Q - 1118) on red deer bone at

Thorpe Common, 3900 ±80 b.c. (Q - 788) from March Hill II, 3880 ±110 b.c. (Q - 1190) from Rocher Moss South 2, 3660 ±120 b.c. (Q - 1189) for Lominot 4, and 3430 ±80 b.c. (Q - 799) appear to confirm the existence of Later Mesolithic industries in the region up until at least approximately 3500 b.c..

In the south of England, however, there appears to be a paucity of reliable radiocarbon evidence relating to fourth millenium b.c. Later Mesolithic industries. At Wakefords Copse, Hampshire, a pit containing Mesolithic flintwork has been dated to 3730 ±120 b.c. (HAR - 233) (Bradley and Lewis 1974). However, the dates of 3780 ±150 b.c. (BM - 91) and 3710 ±150 b.c. (BM - 40) from the site of High Rocks 'F' (Money 1960, 1962) have been questioned as to their accuracy (Jacobi 1982: 21) in the light of the association of the Mesolithic material with pottery sherds 'too evolved to be associated with (the) dates' (Jacobi op.cit.: 21). Similarly, the date of 3310 ±130 b.c. (BM - 449) from the 'pit-dwelling' at Wawcott Farm (site 1) (Froom 1972) has been doubted with regards to its association with the Mesolithic industry (Jacobi 1982: 21).

Taken together with the earliest dates for known Neolithic activity in southern and south-eastern England the radiocarbon evidence for the latest occurrence of Mesolithic industries appears to confirm that such technologies were replaced by Neolithic industries, <u>at the latest</u>, by the end of the second quarter of the fourth millenium b.c., and may reflect, in south-eastern areas, a somewhat earlier replacement.

In the discussion of Mesolithic chronology and typology thus far the evidence from Scotland has been deliberately excluded. The central reason for providing a separate discussion of Mesolithic chronology in Scotland is that, at present, our understanding is having to undergo a radical 'overhaul' in the light of new radiocarbon evidence and the re-examination of evidence of long standing. The importance of Scottish Mesolithic chronology lies, not only in its own inherent interest, but also because Scotland has provided sites with conditions of faunal preservation which may prove crucial to the discussion of Later Mesolithic economy.

3) Mesolithic chronology and typology in Scotland

For a considerable time the radiocarbon chronology of Mesolithic industries in Scotland was restricted to a small number of determinations, with the bulk of these deriving from just a few, widely dispersed sites. Leaving aside the dates associated with the so-called 'Obanian' industries of the Western Isles the radiocarbon evidence was confined to the single date from Barsalloch, Wigtownshire (Cormack 1970) of 4050 ±110 b.c. (Gak - 1601) associated clearly with a Later Mesolithic industry, and the sequence of ten radiocarbon dates from the two sites at Morton Tayport (Coles 1971). Of these ten dates, seven are from the large lithic site of Tayport A, and three come from the shell-midden site, some fifty metres from Tayport A, of Tayport B. It can be seen (fig. 16) that the dates at Tayport A range from 6100 ±255 b.c. (NZ - 1191) to 4350 ±150 b.c. (Gak - 2404), with five of the dates falling in the fifth millenium b.c.. The three Tayport B dates of 4432 ±120 b.c. (Q - 981) and 4197 ±90 b.c. (Q - 988), for the lower midden levels, and 4165 ±110 b.c. (Q - 928) for the upper levels suggest occupation at that site during the latter half of the fifth millenium b.c., with a slight overlap of dates with those from Tayport A.

Industrially, the lithics from Tayport B have generally been regarded as 'undiagnostic' (Mellars 1974: 96-7) whereas the large industry from Tayport A has been regarded as 'non-geometric' (Mellars op. cit.: 96), or Earlier Mesolithic in character. Given the apparent association of seven dates, five of which fall in the fifth millenium b.c., with a non-geometric industry the

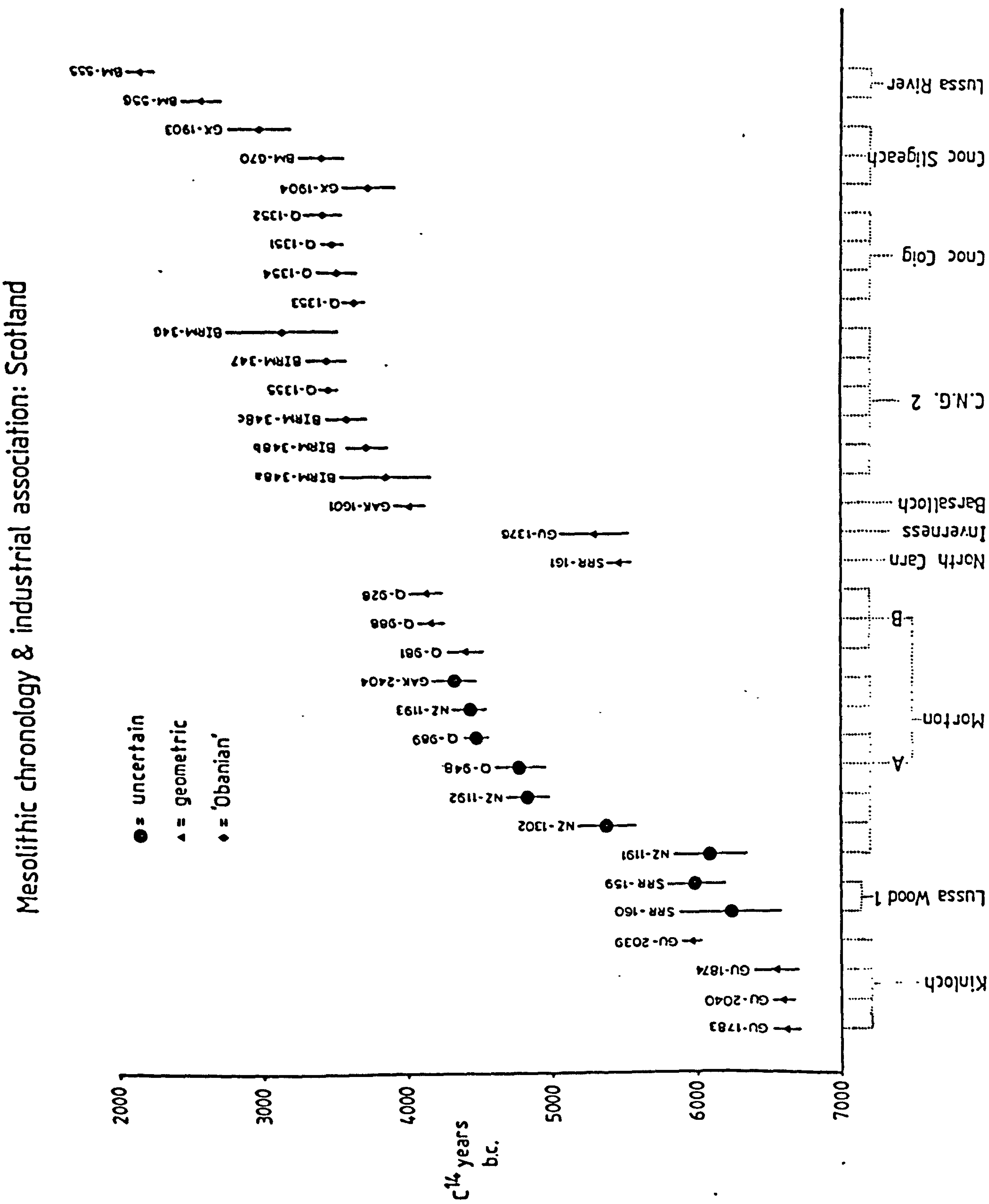

Mesolithic chronology & industrial association: Scotland
● = uncertain
▲ = geometric
◆ = 'Obanian'
C14 years b.c.
2000
3000
4000
5000
6000
7000
Lussa River
Cnoc Sligeach
Cnoc Coig
C.N.G. 2
Barsalloch
Inverness
North Carn
Morton
A
B
Lussa Wood 1
Kinloch
BM-555
BM-556
GX-1903
BM-670
GX-1904
Q-1352
Q-1351
Q-1354
Q-1353
BIRM-347
Q-1355
BIRM-348c
BIRM-348b
BIRM-348a
GAK-1601
GU-1376
SRR-161
Q-928
Q-981
GAK-2404
NZ-1193
Q-969
Q-948
NZ-1192
NZ-1302
NZ-1191
SRR-159
SRR-160
GU-2039
GU-1874
GU-2040
GU-1783

fig.16

seeming implications were that Earlier-types of industry survived in Scotland up to the end of the fifth millenium b.c., some two and a half thousand years later than their disappearance in England!

Further confusion arose with the publication of dates from two sites on the Isle of Jura. At Lussa Wood 1 (Mercer 1974) dates of 6244 ±350 b.c. (SRR - 160) and 6013 ±200 b.c. (SRR - 159) in apparent association with a non-geometric industry seemed to confirm the survival of Earlier industries in Scotland beyond 6500 b.c., whilst the date of 5464 ±80 b.c. (SRR - 161) from North Carn (Mercer 1972) appeared to indicate the replacement of Earlier forms by geometric industries prior to the latter half of the sixth millenium b.c.. It now appears that the industry at Lussa Wood 1 also contains Later elements and we cannot be sure of the actual industrial association with the dates (C. Bonsall pers. comm.; C. Wickham-Jones pers. comm.).

In the light of these doubts the sequence of secure dates from Farm Fields, Kinloch (Wickham-Jones, n.d.; Foyatt pers. comm.), in association with a geometric industry manufactured from local bloodstone, of 6640 ±95 b.c. (GU - 1873), 6565 ±150 b.c. (GU - 1874), 5975 ±65 b.c. (GU - 2039) and 6610 ±75 b.c. (GU - 2040) appears to establish the presence of Later-type industries by the mid-seventh millenium b.c. in at least the western regions of Scotland. Add to this the single date of 5325 ±235 b.c. (GU - 1376) for a sealed geometric industry at Castle-Street, Inverness (Wordsworth 1985; Foyatt pers. comm.) and it would now appear that the associations of dates and industries at Morton Tayport A and B are in need of re-examination.

A number of points concerning the dating evidence and industrial associations at Morton Tayport A and B can be made on the basis of the published report (Coles 1971). First, the sequence of three dates from the midden site came from secure stratigraphic contexts within the midden

(Coles op. cit.: 345) and there are few reasons for doubting their accuracy. Industrially, the midden site produced an assemblage of just over 370 pieces, most of which cannot be used in a 'diagnostic' sense. However, one microlith was recovered, and from the published illustration (Coles 1971: fig. 14 no. 2) this is clearly a Later Mesolithic form.

Secondly, of the seven dates from Tayport A three (Q - 948, NZ - 1192, NZ - 1302) were composite samples from a variety of contexts. Of these, one (NZ - 1302) combined charcoal from the hearth in T43, the occupation surface of T44 and the sequence of occupation floors from T46. As Coles (op. cit.) noted, this date 'is unfortunately a split one, and of only general use.' (332). The date of 4840 ±150 b.c. (NZ - 1192) combined charcoal from occupation 2 and the overlying occupation 3 in squares T47/55/56. Significantly, none of the illustrated associated artefacts (Coles op. cit.: fig. 27) within T47.2 can be regarded as typologically diagnostic, whilst the underlying occupation of T47.1 (Coles op. cit.: fig. 25 no.'s 13 - 22) did produce at least one large Earlier type of microlith (no. 18). Once again, the date of 4785 ±180 b.c. (Q - 948) using charcoal from the T43 hearth and T44 occupation surface, on the basis of illustrated tools (Coles op. cit.: fig.'s 22 and 23), was not associated with any forms characteristic of an Earlier industry.

Of the remaining dates, the determination of 4350 ±150 b.c. (Gak - 2404) from T42 was made on 'decayed wood found in stake holes' (332), but unfortunately the 'associated stone industry was not recovered intact' (333), and none are illustrated. Two dates, 4450 ±125 b.c. (NZ - 1193) and 4500 ±80 b.c. (Q - 989) came from a hearth in T53, but although some lithics were associated with the hearth (326) none were illustrated. The final date, 6100 ±255 b.c. (NZ - 1191) provides us with the earliest date for the two sites, and represents a combined sample from occupations 1 to 6 in area T46 (326). Once again, of those lithics illustrated from T46 (Coles op. cit.: fig.'s 19, 20) only one flint can be regarded as being sufficiently typologically distinctive as to indicate an Earlier or Later occupation,and it (no. 5, fig. 19) is clearly a Later form. Interestingly, this microlith was excavated from the initial occupation in T46.

Taken together, therefore, on the basis of the published report none of the seven carbon dates can be clearly associated with tool forms diagnostic of an Earlier, non-geometric industry. On the contrary, the published evidence from T47 appears to demonstrate the presence of non-geometric forms prior to 4840 ±150 b.c., whilst the stratigraphic evidence from T46 appears to indicate the presence of geometric, Later microlithic forms by at least 6100 ±255 b.c..

We are, as a result, confronted with the possibility that despite the presence of a large industry containing many non-geometric types (see Coles op. cit.: fig.'s 11, 12) none of these can be unequivocally associated with any one of the seven radiocarbon dates. Indeed, the presence within the industry of a number of Later microlithic types (i.e. fig. 11, no.'s 17, 11, 33), and the positive stratigraphical evidence from T46 might lead us to conclude that the site was occupied at some time prior to 6100 ±255 b.c. by groups using an Earlier technology, and was also occupied at c. 6100 b.c. by groups with a Later technology.

If one accepts this reappraisal of the chronological evidence from Morton three important conlusions can be derived:

(1) All available radiocarbon evidence from Scotland that can be securely associated with lithic industries (excluding the 'Obanian') relates to geometric or Later type technologies.

(2) On the basis of (1), it would appear that the transition to geometric or Later type technologies took place in Scotland prior to the middle of the seventh millenium b.c..

(3) The important faunal evidence for Morton Tayport B can now be securely associated with Later Mesolithic (on typological/industrial grounds) exploitation during the mid - late fifth millenium b.c..

4) Duration of Mesolithic in Scotland

Evidence for the duration of Mesolithic industries is, once again, subject to certain complexities and regional bias. In the Western Isles of Scotland it has long been recognized (Movius 1940) that early excavations at sites such as MacArthur Cave, Mackay Cave, Distillery Cave, Gasworks Cave, Dunollie Cave and Druimvargie rock shelter (Anderson 1895, 1898; Turner 1895) had revealed an unusual 'cultural' assemblage peculiar to the area around Oban. These 'Obanian' sites produced a wide range of tool forms made from antler and bone associated with the exploitation of a wide range of shellfish and other coastal resources. Subsequent work on the island of Oronsay (Jardine 1977; Mackie 1972, Mellars 1978; Mellars and Payne 1971; Peacock 1978) has thrown considerable light upon the economy, technology and chronology of the Obanian. Radiocarbon dates from the shell-middens at Cnoc Coig, Caisteal nan Gillean II and Cnoc Sligeach (fig. 16) provide a sequence of thirteen dates whose means all fall within the fourth millenium b.c.. Despite extensive sieving of excavated material, however, none of the Oronsay sites have produced a single distinctive microlith (Mellars and Payne 1971: 398; P. Mellars pers. comm.). The lithic industries at these sites consist, instead, of bipolar flakes and cores/tools (lames ecaillés) manufactured from local poor-quality beach-flint and quartzite - a common technological response to the manufacture of generalized tools from low-grade materials

(Forsman 1975; McBryde 1982; J.P. White pers. comm.). The presence on nearby Jura of an industry dated to 2250 ±100 b.c. (BM - 555) and 2670 ±140 b.c. (BM - 556) at Lussa River (Mercer 1971) which combines geometric microliths with bipolar tools and waste identical to those on Oronsay raises a number of questions concerning the relationship between 'Obanian' sites, and the more widespread geometric industries of the Later Mesolithic, which cannot be entered into here. It would appear, however, that in parts of western Scotland, at least, hunting, gathering and fishing technologies may have persisted into the third millenium b.c., contemporary with and, in some cases, later than Neolithic activity represented at sites such as Dalladies (3240 ±105 b.c. (I - 6113))and Monamore (3160 ±110 b.c. (Q - 675)).

In other regions of Scotland dates associated with possible 'late' Later Mesolithic activity come from Muirtown, Inverness (Myers and Gourlay in prep.) where a hearth at the base of a shell-midden has produced a date of 3685 ±65 b.c. (Gu - 1473), and at Inveravon (Mackie 1972) where dates of 4060 ±180 b.c. (Gx - 2331) and 4005 ±180 b.c. (Gx - 2334) were obtained from another shell-midden. Neither of these sites, however, have produced a diagnostic lithic industry, in which case we might conclude that present evidence allows us to establish the presence of Later Mesolithic industries, outside of the Western Isles, only up to the end of the fifth millenium b.c. (i.e. Barsalloch).

General summary

On the basis of available radiocarbon evidence our understanding of the chronological development of Mesolithic industries on the British mainland can be seen to be far from complete. Whilst there appears to be evidence for a general typological transition from non-geometric to geometric industries in England, Wales and Scotland our ability to detect, with meaningful precision, the chronology of these Mesolithic developments remains regionally uneven. Whilst our understanding of the initial appearance of Earlier Mesolithic industries in northern and southern England is reasonably well founded the evidence from Wales and Scotland does not allow us to draw specific conclusions. In Wales Earlier Mesolithic dates appear to refer to the latter stages of the Earlier Mesolithic, whilst in Scotland it now appears that, as yet, we do not have a single date reliably associated with an Earlier Mesolithic industry.

Similarly, the chronology of the transition to geometric industries is better understood in northern England than in any other region. On the basis of available radiocarbon evidence, and allowing both for standard deviations and the possible over-emphasis of the single date from Filpoke Beacon, we can say with confidence that the transition from Earlier to Later Mesolithic industries had been achieved in northern England no earlier than approximately 6800 b.c., but at some time prior to approximately 6600 b.c.. Elsewhere, however, our capacity to define a transitional date is limited by the availability of relevant radiocarbon dates and our poor chronological understanding of possible intermediary developments (i.e. Wealden technologies - *sensu* Jacobi 1981). In Scotland, however, the known date for the appearance of Later Mesolithic industries can now be pushed back in time to at least the earlier half of the seventh millenium b.c., broadly contemporary with the evidence from northern England.

From the preceding discussions of early post-glacial environmental changes and Mesolithic chronology a number of points can be made. On the basis of our understanding of Earlier Mesolithic chronology in England it would appear that the first appearance of such industries corresponds with the development of increasingly forested conditions in place of the more open, tundra vegetation of the late glacial. Accompanying these floral changes the Earlier Mesolithic saw the rapid replacement of typically late-glacial faunal species by a more diverse range of forest/forest edge species. In terms of sea-levels the Earlier Mesolithic saw Britain attached to the continent and Ireland by an extensive, low-lying land-bridge which we know has produced artefactual evidence for man's presence. It has long been recognized that certain British Mesolithic industries bear a strong typological similarity to the Maglemosian industries of Denmark, southern Sweden, north Germany, the Low Countries and northern France (i.e. Clark 1936; Peake and Crawford 1922). Jacobi (1976, 1978a: 295) has proposed that these industries be collectively subsumed under the descriptive term - the north European 'Maglemosian technocomplex'. Besides the similarities in lithic industries exhibited by British and north European Maglemosian industries certain elements of non-lithic technology, such as uniseral bone/antler points, are also held in common. The presence of such industries on both sides of the North Sea basin, and the presence of uniseral points within the North Sea basin further emphasizes the importance of the land-bridge in the Earlier Mesolithic period.

Climatically, whilst the Earlier Mesolithic witnessed a steady increase in temperatures it is interesting to note that, according to Taylor's estimates fig. 13) the major upturn in mean annual and mean winter temperatures for land below 500 m began and was sustained from c. 7000 b.c. until c. 6000 b.c.. Similarly, the evidence for mean annual temperature ranges (fig. 14) indicates that the major period of reduction, or amelioration, fell in the same period. This evidence broadly corresponds with the period for the most rapid rises in relative sea-levels and would appear to be linked. For human populations the implied loss of land and resources due to rising sea-levels may have been most significant during this period (see Jacobi 1980b: fig. 4.3). Furthermore, the effects of progressive climatic amelioration appear to broadly correspond with the development of an increasingly diverse woodland with the establishment of thermophilous, deciduous species and the initiation of the progression towards the climax mixed-deciduous forests of the Atlantic period. In this light, the documented transition from Earlier to Later Mesolithic in northern England at c. 6800 - c. 6600 b.c., and the clear establishment of Later Mesolithic industries by c. 6600 b.c. in Scotland, can be seen to fall during a period of rapidly changing environmental conditions. At this point, however, no causal link is assumed - it is merely interesting that these developments appear to correspond broadly in time.

Chapter Four:

Economy, settlement and technology

Introduction

One of the outstanding features of Mesolithic research in Europe during recent years has been the diversity of perspectives concerning economy, settlement patterns and technology that have been applied in different regions. For example, studies have variously emphasized the roles of hunting (Clark 1972; Jacobi 1978a; Jochim 1976; Mellars 1975, 1976b), fishing (Jochim 1979) and plant food gathering (Clarke 1976; Jacobi 1978b; Mellars 1976a: 375) in Mesolithic economies. Similarly, perspectives on settlement and mobility have ranged between, for want of more precise terms, 'the highly mobile' (i.e. Jochim 1976), and 'the largely sedentary' (Rowley-Conwy 1981, 1983, 1984; O'Shea and Zvelebil 1984). Whilst much of this diversity undoubtedly reflects the considerable range of adaptations amongst post-glacial hunter-gatherer societies in Europe (see Price 1983) it also underlines some of the fundamental theoretical and methodological challenges confronting Mesolithic research. It is no longer adequate or appropriate that traditionally held assumptions concerning the primacy of hunting be maintained, or that discussions of Mesolithic settlement and mobility remain confined to the normative view that hunter-gatherers 'live in small groups and ... move around a lot' (Lee and DeVore 1968b: 11).

Discussions of Mesolithic adaptations on the British mainland have, through their diversity of perspectives and somewhat contradictory implications, emphasized further the methodological problems associated with the refinement of models concerning economy and settlement. As previously indicated, the archaeological record for the period has remained dominated by sites offering conditions unsuitable for the preservation of organic evidence for Mesolithic economic activities. Ironically, the comparative scarcity of sites producing faunal or floral evidence for Mesolithic subsistence has, in part, served to ensure that considerable attention be given to those few sites with such evidence, with the result that, in terms of perspectives on economy and settlement, the bulk of Mesolithic site evidence has made only a subordinate contribution. In the following sections attention will be drawn to existing perspectives on Mesolithic economy, settlement patterns and technology with a view to identifying and assessing important issues requiring further examination.

Economy

1) Plant-foods

Recent years have seen the discussion of Mesolithic economies on the British mainland shift away from the more traditional emphasis on the role of hunting to include consideration of the evidence for plant-food collection and the role of vegetable resource exploitation. This shift in emphasis has not been brought about through any radical change in the representation of direct economic evidence in the archaeological record, but rather through changing perspectives of hunter-gatherer economies - particularly as voiced in the 'Man the Hunter' symposium of 1966 (Lee and DeVore 1968a). Prior to the publication of the symposium a number of lists had been compiled containing edible plant species which may have been available for exploitation by Mesolithic groups (Clark 1952: 59 - 61, 1954: 14; Dimbleby 1967: 26 - 42). However, it was the formulation of the normative model of hunter-gatherer behaviour, including the observation that amongst documented hunter-gatherers plant-foods, in the majority of cases, formed the dominant food supply, which stimulated the serious consideration of the role of vegetable resources in Mesolithic economies. Noting the work of Lee (1968: 42-3) the new perspective of Mesolithic economies was clearly stated by Mellars:

> 'The obvious inference to be drawn from these observations would seem to be that amongst Mesolithic communities occupying the densely forested regions of temperate Europe the collection of plant-foods is likely to have made a substantial - if not dominant - contribution to the overall food supply.'
>
> (1976a: 375-6: - my emphasis).

In turning to the available evidence from Mesolithic sites it was the documented presence of hazel-nut shells on some twenty sites, and the existence of notable concentrations at at least three - Filpoke Beacon, Lussa River and Oakhanger VII - which provided the basis for speculation as to their role in Mesolithic economies.

Mellars (op. cit.) identified two principal roles which hazel collection may have represented. The durability of hazel-nuts led Mellars (376) to suggest that they may have been collected throughout the winter from the forest floor. More importantly, Mellars suggested that,

> 'Indeed, the major economic importance of hazel-nuts ... may well have been as a critical stand-by food resource for use during the winter season when food supplies in general were not only scarce but also subject to unpredictable fluctuations.'
>
> (op. cit.: 376).

A number of important and potentially contradictory implications stem from these speculations. First, if hazel were to fulfil the role of a 'substantial - if not dominant' food supply then this would not appear to correspond with their suggested role as a 'critical stand-by' when all else failed. Secondly, and more significantly, if it is suggested that hazel collection served to provide resources for over-wintering it is most unlikely that such collection activity would be left until the winter - the time when they are most needed - since this strategy would engender considerable levels of risk for the consumers. Furthermore, whilst hazel is a durable resource it is most unlikely that, in the face of competition from other nut-collecting foragers - such as squirrels - sufficient supplies would remain into the winter period for collection from the forest floor. As Mellars noted,

> 'A more likely contingency, however, is that large stocks of nuts were built up during the autumn and deliberately stored for use during the winter months.'
>
> (op. cit.: 376).

Here, then, we have a clearly stated theoretical role for hazel collection (and by extension - other autumnal fruiting species) as a seasonally critical resource for over-wintering through anticipatory autumnal collection and storage. General support for this suggested role for autumnal fruiting species has been voiced (Clarke 1976: 474-5; Jacobi 1978b: 82) with particular reference to the potentials for nut exploitation on the light, sandy soils of the Lower Greensand deposits in southern England. Clarke (op. cit.) correctly identifies the major resource challenge of hunter-gatherers living in the temperate forest zone as being that of over-wintering 'in an ecology that had effectively shut down for several months.' (474). In suggesting that plant-food collection and storage may have provided one solution Clarke recognized that such a strategy would imply,

> 'an intensive period of communal autumn gathering, preparation and storing in pits and baskets, which then must serve as a base-area for the rest of winter.'
>
> (op. cit.: 474).

A number of important archaeological implications stem from this model of intensive autumnal anticipatory collection and storage. As Clarke recognized, unlike the anticipatory caching of meat supplies away from residence sites we would expect, given the energy constrained, bulk nature of plant food harvesting (see previous chapter), the caching/storage of plant-foods to take place on-site. Although it could be argued that nut storage, for example, need not entail complex storage facilities the critical over-wintering role suggested might lead us, as Clarke emphasizes, to expect some investment in secure storage. Similarly, the bulk nature of the product of such intensive gathering (see Jacobi 1978b: 82-3) might be expected to 'tie-down' the settlement mobility and promote further investments in storage facilities.

Despite Clarke's (op. cit.: 475) enthusiastically optimistic interpretation of site evidence from the Wealden district there are, to date, no site features which can confidently be associated with such bulk-storage behaviour. At Selmeston (Clark 1934), for example, fragments of hazel-nut shells were recovered in small numbers from 'pit-dwelling' 1, but so were numerous calcined flints and an unidentified bone fragment (op. cit.: 139 - 140).

No hazel-nut shells were recovered from pit 2 (140), whilst a single fragmentary hazel-nut shell was recovered in association with 298 calcined and over 1200 worked flints from pit 3 (140). Such evidence hardly provides us with a confident picture of bulk hazel-nut storage in these features. The paucity of structural evidence for bulk plant-food storage need not, however, imply the absence of such behaviour given the general poverty of Mesolithic structural evidence.

More important, perhaps, is the virtual absence of tool forms which might be functionally associated with plant-food harvesting and processing. The work of Keene (1981) is of particular relevance with regard to the role of plant-foods and technology. Using optimal-foraging principles to examine the cost-benefit relationship for exploiting a wide range of resources in the temperate forest environment Keene considered the predicted roles of, amongst other resources, acorn, hazel, tuber and weed seed exploitation (op. cit.: 54 - 91). For nut exploitation Keene found that in all cases processing costs constrained their comparative utility:

> 'Note that a reduction in cost of nearly 95% is necessary for most nut foods before they become equivalent in cost-benefit to other resources.'
>
> (174).

Keene predicted that nut exploitation would only achieve a primary importance when costs of exploitation were reduced, possibly through the enhancement of nut-processing technology, and that otherwise their exploitation would remain non-intensive (175-6). Similar conclusions were derived for the exploitation of other plant-foods such as weed-seeds (177). Although one may question the comparability of Keene's study area with Mesolithic Britain it remains a study of temperate forest exploitation and of potential significance to other temperate forest regions.

At this point it is appropriate to briefly consider one of the major elements in Clarke's (1976) argument - namely the functional interpretation of microlithic technology. Quite correctly Clarke questions the traditional assumption that microliths are equated solely with hunting technology. Certainly, the post-glacial period saw the widespread development of composite technologies employing microlithic elements in their construction. Certainly, there is considerable archaeological and ethnographic evidence for the use of composite microlithic tools in plant harvesting and processing as well as for hunting and fishing (op. cit.: 453-55), and it is clearly untenable to suggest that all microlithic forms in all regions of the world relate to hunting. What is important, however, is that all the available evidence from Britain indicates that during the Mesolithic period microliths were components of projectile technology. In contrast, evidence for the use of microliths in vegetable harvesting and/or processing has not, as yet, been forthcoming. This subject will be dealt with in more detail later on.

Given the projected bulk nature of plant-food storage for over-wintering, and given Keene's observations on the relationship between processing costs and technology, might we not expect to see - under the over-wintering model - evidence for a technology associated with the reduction of processing costs? In the light of this expectation the dearth of pounders, grinders and mortars in Mesolithic assemblages is probably highly significant. A possible exception comes from Oakhanger VII, previously noted for its notable concentration of hazel-nut shells, where a number of modified slabs were found (Jacobi pers. comm.; Rankine and Dimbleby 1960: 252), but even here the function(s) of these items remains uncertain.

That plant-foods would have been available and known by Mesolithic communities in Britain is beyond doubt. The range of edible species found in the mud associated with the cultural evidence at the Earlier

Mesolithic site of Star Carr (Clark 1954, 1972) tells us that from the Earlier Mesolithic onwards such opportunities would have existed. Similarly, the progressive amelioration of the climate and shift towards a mixed-deciduous forest may have seen an increasing diversity and extended growing season for plant-food resources. That such resources were available and almost certainly exploited, at some level, is not open to question. The important issues are to what level of intensity and to what economic goal was such exploitation geared? For the present, at least, it would appear that very little evidence for intensive, critical exploitation - either in the form of physical remains, site storage features or processing technology - can be claimed from the archaeological record. In other words, the intensive autumnal collection of fruiting species for winter storage remains little more than an intriguing possibility, and at present the evidence (or absence thereof) indicates that plant-food exploitation during the period was probably non-intensive and that consumption was constrained to seasons of availability.

2) Coastal resources

In discussing the nature of coastal resource exploitation during the Mesolithic a number of important cautionary points must be made. First, one of the principal effects of the rapid rise in sea-levels during the period prior to the sixth millenium b.c. was to submerge considerable areas of pre-existing coastal lands. Consequently, we have little or no direct site evidence for the coastal resource exploitation strategies of Earlier Mesolithic groups, and all of the known evidence relates to the sixth millenium b.c. and later. In other words, although the available evidence for the exploitation of specifically coastal resources (shellfish, marine fish, crustaceae, sea-birds, marine mammals etc.) derives from Later Mesolithic contexts this does not, of itself, imply that such resources were not exploited during the Earlier period.

Secondly, almost all of the direct economic evidence for coastal resource exploitation is derived from shell-midden accumulations where the durable and protective matrix, good drainage and alkalinity serve to preserve a range of organic economic evidence. Whilst it is inevitable that discussions will focus upon the evidence from such sites it must be recognized that coastal resource exploitation may not always have involved shellfish collection and that we are observing a heavily biased record of economic activity.

a) Shellfish

Following on from the previous point, the occurrence of large accumulations of shellfish incorporating other forms of economic evidence may, superficially, appear to provide us with a uniform category of site amenable to explanation. Such an assumption would, however, ignore the considerable diversity in site location, structure and content that can be observed for such sites. It must be remembered that the 'unifying' element - shellfish collection - despite the sometimes impressive quantities represented, was probably an activity of relatively minor importance in terms of annual dietary contribution (c.f. Bailey 1975: 45). It is interesting to note that Mellars (1976a: 381), in discussing the potential value of coastal resources, emphasized the predictability - or low-risk - of shellfish exploitation as a factor influencing winter exploitation patterns. Whilst shellfish collection may be relatively expensive in cost-benefit terms (see previous chapter) certain locations may offer a dependable supply of nutrition with little or no risk of failure. Bonsall (1978) has emphasized the locational advantages of shell-middens such as those on Oronsay, Risga and Portland for maximizing available inter-tidal cropping area within a minimal distance from the site. As with all bulk high-input/low-return resources transportation costs can constrain utility.

Consequently, although shellfish collection may not provide a primary dietary element it may, in the final analysis, exert a constraining factor on site placement, from which other activities might be undertaken.

The idea that shellfish may have introduced a reliable low-risk dietary input would achieve its most meaningful role during winter months when the alternative primary source of low-risk input - vegetable foods - would have been greatly reduced in availability. Support for winter shellfish exploitation has recently come from a detailed study of growth-lines on Cerastoderma edule (L) samples from the midden at Morton Tayport B (Deith 1983) where the results indicated a pattern of predominantly winter collection with a brief episode of collection during June/July.

The degree to which shellfish collection may have provided a reliable low-risk resource can be expected to vary with species, location and rate of cropping. Whilst it has long been established that intensive cropping of bivalve populations may detrimentally alter the size range and productivity of the standing crop (Hancock and Urquehart 1966; Swadling 1976) it may be that vulnerability to cropping will vary according to species and between locations. At Culver Well (Palmer 1976) a study of size-range distributions for three species (Patella sp., Littorina littorea, Monondonta lineata) represented in column samples taken from the midden revealed a consistent decrease through time in the mean sizes of all three species (fig. 17) providing confirmation of the previously stated view that the Portland shellfish populations were being overcropped (Evans 1974, 1975: 104; Jacobi 1978b: 81). However, the effects of cropping upon the Portland shellfish population may have been amplified through high spat-loss rates due to the twin tidal currents around Portland (Pingree and Maddock 1977) and seasonally induced reductions in the standing crop through the migration of

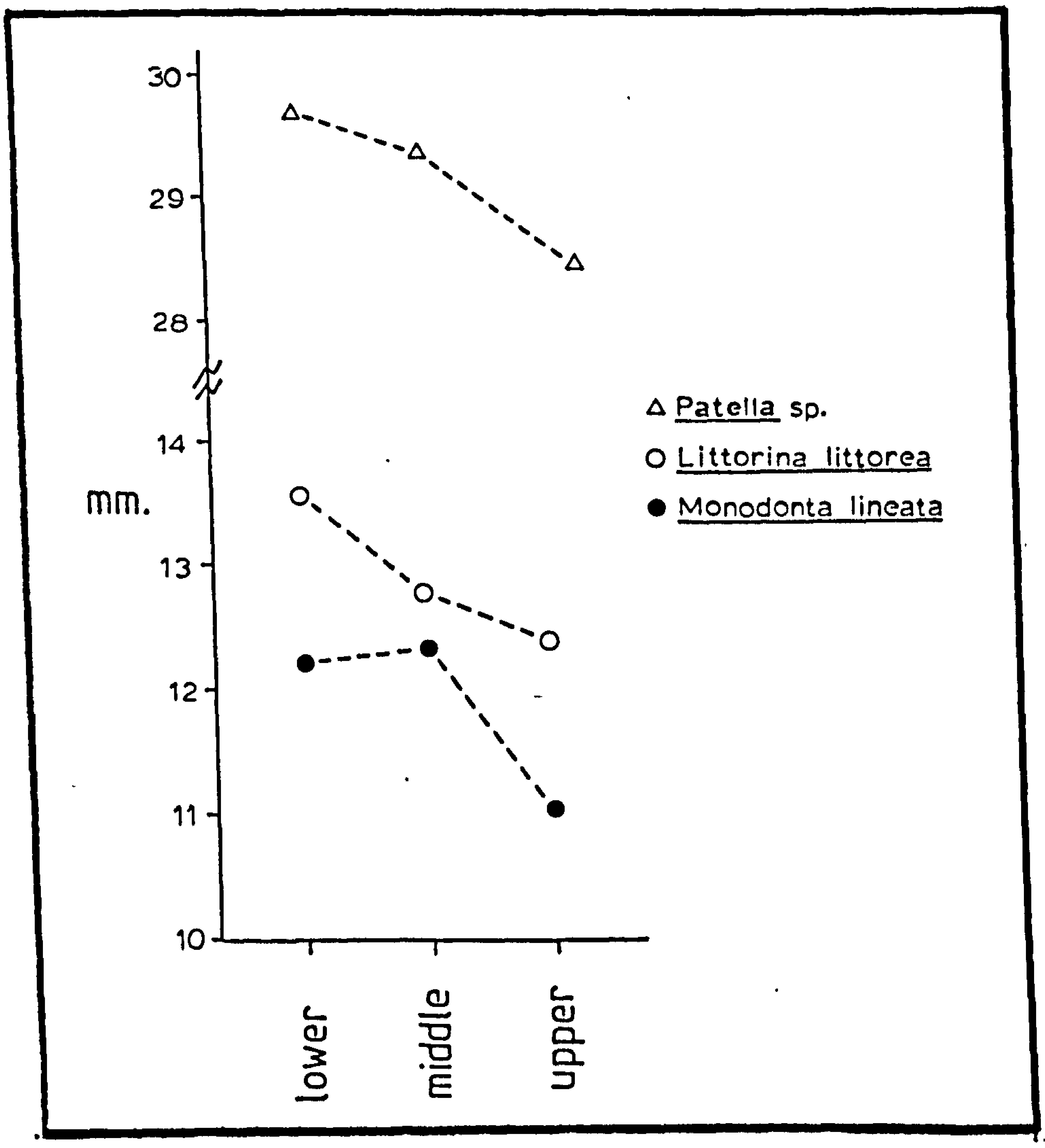

30
29
28
14
13
12
11
10
mm.
Patella sp.
Littorina littorea
Monodonta lineata
lower
middle
upper

fig.17

M. lineata to below the waterline after early - mid November (Desai 1966: 12 - 13). Therefore, the cropping of shellfish on Portland need not have been intensive or prolonged to produce an impact.

At the Obanian sites on Oronsay (Mellars 1978) it appears that cropping of Limpets produced little or no change in size ranges through time (D. Jones pers. comm.), reflecting either the non-intensive cropping or the inherent abundance and stability of Limpet populations in the area. Significantly, whereas the site of Culver Well has produced little alternative economic evidence the Oronsay middens have produced a wide range of dietary evidence beyond shellfish collection. A similar diversity of subsistence inputs has been recorded from other Obanian sites, as well as from the middens at Morton Tayport B (Coles 1971), Westward Ho! (Churchill 1965) and, less certainly, Blashenwell (Reid 1896) where only a very small number of shellfish were recovered (Jacobi pers. comm.). For Culver Well, the view that the occupation was primarily concerned with lithic procurement and replenishment from the local Portland chert sources (Evans 1975: 104 - 105; Jacobi 1978b: 81) seems increasingly likely and that the shellfish provided a convenient dietary input for a series of short-lived industrially-related occupations.

In general, therefore, the shellfish collection evidence provides us with a view of a resource of secondary importance which possibly achieved an important role during winter months as a useful low-risk option. For many sites the dietary importance of shellfish appears to be overshadowed by alternative resources - some exclusively coastal and others not so - or by alternative subsistence-related goals such as technological refurbishment. Before proceeding to examine the limited evidence for other forms of coastal resource exploitation it is appropriate to briefly mention the evidence from Inveravon (Mackie 1972) and Muirtown (Myers and Gourlay in prep.). At both of these sites evidence for shellfish collection from estuarine locations occurs, associated with Mesolithic dates, with little or no evidence for either alternative economic or industrial activity. Spatial and stratigraphic evidence at Muirtown indicates that the area was visited on numerous occasions for very short periods of time. The specialized role but sporadic nature of shellfish collection at Muirtown might suggest that such sites represented the repeated, short-term visitations of individuals or groups solely for the purpose of consuming shellfish and that they do not represent residence sites. Such a pattern of exploitation may have continued into the later prehistoric period in the area (Sloane 1982).

b) Sea-fishing

Direct evidence for sea-fishing during the Mesolithic comes from the middens at Morton Tayport B (Coles 1971), Risga (Lacaille 1951, 1954; Mann 1920), and on Oronsay (Mellars 1978). At Morton bones of five species (cod, haddock, turbot, sturgeon and salmon/sea-trout) were identified, but of these cod provided the overwhelmingly dominant number of bones. The evidence for cod fishing has been taken as indicating fishing from boats in deep water whilst the salmonid and sturgeon were thought to represent exploitation of migrations into or out of the shallow waters of the river mouth (Simmons et al. 1981: 121). In general, sea-fishing is thought to have been primarily a 'warm-weather' activity (March - November) when many species move into shallower waters to feed (Jacobi 1979a: 82), whereas the exploitation of riverine migrations is expected to have coincided with the up-stream movement, when the fish will be at their peak of condition, during May - June.

On Oronsay, the evidence for seasonality in the exploitation of Saithe (Pollachius virens) suggests that at Cnoc Sligeach and Cnoc Coig fishing was largely confined to mid-summer and autumn respectively whilst at the Priory midden the evidence from all but the upper levels indicates limited fishing during winter and early spring (Mellars 1978: 383-5). Despite the comparative abundance of fishing evidence on Oronsay, in terms of meat-weight contribution shellfish provided consistently more than fishing (Mellars op. cit.: 378), except in sample 3 from the Priory midden. Even so, Mellars considered it quite possible that shellfish collection was primarily a winter and early spring activity 'when most other sources of food were either inaccessible ... or in very short supply.' (385).

The midden on Risga, Loch Sunart, has produced evidence for sea-fishing in the form of seven identified species, although no quantification of the remains is available. Amongst the array of bone and antler tools recovered was one possible fish hook, made of bone, which has been taken as evidence for line fishing (Morrison 1980: 161).

c) Riverine fishing

If evidence for sea-fishing during the Mesolithic remains confined to just a few sites and difficult to generalize upon then the evidence for riverine fishing is almost non-existent. The discovery of pike bones at Foxhole Cave (Bramwell 1971) and Dowel Cave (Bramwell 1959) represent the sum total of direct evidence for freshwater exploitation during the period. Although the absence of evidence from sites such as Star Carr has been accounted for (Wheeler 1978) it seems far from credible to suggest that such resources were ignored during the Mesolithic. The association of a barbed point in association with pike fins at Skipsea (Godwin 1933) has been claimed as further evidence but the association with reindeer and 'giant elk' has led to doubts concerning the age of the deposits (Simmons et al. 1981: 120).

Whilst the absence of direct evidence may well reflect poor preservation and/or inadequate recovery techniques a number of points may prove important in considering the nature of riverine fishing. Ethnographic evidence from such areas as the north-west coast of America (Suttles 1968; Piddocke 1969; Donald and Mitchell (1975) suggests that in order to maximally exploit seasonal runs of anadramous fish for over-wintering several organizational and environmental conditions must be met. First, such runs must be sufficiently regularized, predictable and productive to justify the anticipatory construction of facilities for capturing and storing supplies. Second, considerable labour investments are needed both prior to capture (for facility construction) and during/after capture, in order to process (i.e. fillet, smoke) the large quantities of fish. Third, since the storage of such quantities of resources will 'tie-down' the mobility of the group the benefits must be sufficient to merit the risks associated with reduced residential mobility. As Schalk (1977) has emphasized, intensive exploitation of anadramous fish runs may place severe organizational demands upon communities connected with preparation of technology, procuring, processing and storing sufficient quantities that will only be justified in relation to the cost-benefit relationships of alternative, more generalized patterns of exploitation.

Whilst certain areas of Britain will have provided exploitable seasonal runs of anadramous fish (Jacobi 1979a: 82-3) it is far from clear if the benefits of intensive exploitation were sufficient to justify the costs and risks associated with an increased dependency - particularly for over-wintering - on such a specialized strategy. If such strategies were employed during the Mesolithic of the British mainland we might expect to find site evidence for intensive storage/processing activity. Whilst such evidence may yet be found there is, at present, little that would indicate the organizational intensity of such behaviour in the archaeological record. It is interesting to note that the evidence for anadramous fish exploitation from Mount Sandel (upper site) and Newferry 3 (Woodman 1978) derives from the context of the relatively impoverished fauna of early post-glacial Ireland. As Woodman (op. cit.) noted,

> 'The early insulation of Ireland ... served as an obstacle to the immigration of both plants and animals ... as a result ... the fauna and flora of Ireland is rather restricted.... Ungulates such as wild cattle, elk and roe deer are not represented amongst the native fauna of the island.'
>
> (360).

It may well be that in mainland Britain riverine fishing formed a regular component of the annual dietary strategy of Mesolithic groups but it is also possible that the benefits of intensive, specialized fishing were not sufficient to justify the costs and risks of reduced mobility in association with an increased dependency upon such activities. For the present, therefore, we might conclude that although riverine fishing may have contributed to the subsistence strategies of Mesolithic groups on the British mainland it is probably best understood in terms of seasonal, non-intensive exploitation as part of a more generalized strategy.

d) Sea-birds

Direct evidence for the exploitation of sea-birds is, once again, restricted to the middens at Morton Tayport B, Risga and on Oronsay. At Morton, bones of eleven bird species were identified although it is not certain if all of these represent inputs from procurement activities or the chance occurrence of dead birds on or in the vicinity of the midden. Larger numbers of guillemot and, less clearly, cormorant and razorbill indicate deliberate collection, although in terms of dietary contribution it seems unlikely that they formed a major element at Morton.

Similarly, the midden on Risga has produced bones of eleven identified bird species, but the absence of quantification denies any meaningful discussion of their dietary importance.

Generally, the exploitation of sea-birds, both for their meat and eggs, is regarded as probably having been highly seasonal and geared to periods when such resources were readily accessible - primarily in the early to mid spring when birds were nesting, and late spring when the eggs were available (Clark 1952: 40-1; Mellars 1976a: 377). On Oronsay, the evidence for exploitation of a wide range of sea-birds including the flightless great auk, guillemots, razor-bills and eider-duck is thought to have been opportunistically scheduled to seasons when the individual species were most vulnerable (Grigson 1986), with some suggestion of over-exploitation of the vulnerable great auk. Although such resources may have made important seasonal contributions to dietary strategies their overall importance is thought to be as part of a more generalized strategy of coastal resource exploitation.

e) <u>Sea-mammals</u>

The exploitation of sea-mammals by Mesolithic groups is attested by the presence of seal and whale bones in the middens on Oronsay and Risga, whilst discoveries of whale bones associated with artefacts of red deer antler in the transgression deposits of the River Forth (Blackadder 1824; Turner 1889; Morris 1898, 1925; Clark 1947; Lacaille 1954) provide further indications of sea-mammal exploitation. The evidence from Oronsay, and from the site of Cnoc Coig in particular (Mellars 1978), provides the clearest evidence for systematic exploitation. At Cnoc Coig the numerous seal bones, taken with the evidence for primarily autumnal occupation, has led to the suggestion that both seal meat and fish were being intensively processed for winter storage,

> 'since it is at this season of the year that we might expect human groups to have been most concerned with the problems of building up substantial supplies of stored food for use over the ensuing winter months.'
>
> (Mellars 1978: 391).

Certainly, such an interpretation would accord with more general perspectives on the exploitation of seals (Jacobi 1979a: 82) where the ease and benefits of October to mid-November exploitation have been related to the presence, during this season, of breeding groups with their young on 'rookeries' and the fact that outside of this period seal-hunting,

> 'would involve the input of far more energy per weight of meat obtained ....'
>
> (Jacobi op. cit.: 82).

In energetic terms, therefore, autumnal seal-hunting would appear to offer the best opportunities both for dietary and non-dietary (i.e. seal oil, skins for clothing etc.) goals. However, access to regularly occupied breeding sites may have been highly variable (Jacobi op. cit.: 82), according to physical locational factors, and constrained the utility of such exploitation patterns through the introduction of greater energy inputs and risks.

At Cnoc Coig, the evidence of whale bones, clustered on the pre-midden surface (R. Nolan pers. comm.), is difficult to relate to the other activities represented at the site. Certainly, the discoveries from the Firth of Forth indicate opportunistic exploitation of stranded animals, and not the intensive and highly organized exploitation strategies of groups such as the Point Barrow Eskimo (Spencer 1971) where the entire subsistence and settlement schedule is geared to the anticipatory exploitation of seasonal whale migrations.

In general, therefore, the exploitation of seal populations may have achieved an important seasonal status according to the ease and benefits of exploiting autumnal breeding populations. Outside of autumn, seal exploitation will have entailed greater costs and risks thereby reducing its attractiveness in comparison with other subsistence activities. On present evidence, whale exploitation may be confined to the status of a highly opportunistic activity occurring when and where such opportunities arose.

Coastal resources: an overview

From the preceding discussions it will be apparent that evidence for Mesolithic coastal (and riverine) resource exploitation is highly varied and subject to strong regional bias in the character, content and quality of the archaeological record. On the basis of the available evidence it is unlikely that the subsistence economies of Mesolithic groups in general consisted of predominantly coastal resource exploitation (with the possible exception of the Obanian). This is not to say, however, that such resources did not play an important role. Much of the evidence for shellfish and sea-bird exploitation appears to conform to the role of a critical winter and spring exploitation pattern associated with the higher costs and risks of exploiting alternative terrestrial resources during these seasons. Similarly, there is some basis for associating autumnal sea-fishing and seal exploitation with strategies designed to introduce a dependable stored-food supply into the context of winter subsistence. Even so, such strategies may have been locally constrained according to the ease and costs of such intensive autumnal activity.

It is, perhaps, worth considering that whilst the virtues of coastal resource exploitation have been generally extolled the arguments put forward have tended to emphasize the accessibility of terrestrial resources, such as deer, in certain coastal locations during winter months (i.e. Mellars 1976a: 377 and 381). Certainly, the evidence from mainland middens, such as Westward Ho! and Morton Tayport B, indicates a combined exploitation of coastal and terrestrial resources, whilst the pure molluscan content of Culver Well's midden does not appear to indicate anything more than sporadic exploitation of a convenient but vulnerable shellfish population.

Before moving on to consider the evidence for hunting in Mesolithic economies it is worth returning to the question of the chronology of Mesolithic coastal resource exploitation. The possible chronological bias in favour of the Later Mesolithic with regard to evidence for coastal resource use has been previously mentioned. On the basis of available absolute dates for coastal resource exploitation, however, it appears that the earliest dates come from Culver Well, where radiocarbon dates of 5200 ±135 b.c. (BM - 473) and 5151 ±97 b.c. (BM - 960), as well as a less reliable thermoluminescence date of 5400 ±640 b.c. (OXTL - 501 bm) appear to date the activity to the latter part of the sixth millenium b.c.. Of these, however, only the date of 5200 ±135 b.c. can be related to the shell midden accumulation, coming from the basal midden deposit (Palmer 1977: 145), the other two dates relating to a hearth on the surface underlying the midden (Palmer 1977: 146). If we accept the radiocarbon evidence then we can conclude that the dates indicate the earliest shellfish collection during the last quarter of the sixth millenium b.c., in general agreement with the date of 5005 ±140 b.c. (Q - 1211) from Westward Ho!.

On present evidence it would appear that shellfish gathering as an economic activity is not represented in any Later Mesolithic site prior to the latter quarter of the sixth millenium b.c., with the dating evidence from Westward Ho!, Blashenwell, and Morton Tayport B indicating a fifth millenium b.c. date for the expansion of such activities. Once again, it may well be that future dates will confirm shellfish exploitation earlier than c. 5200 b.c., but at present such evidence is lacking.

3) Hunting

Of the various possible subsistence activities which Mesolithic groups may have engaged in it has been the role of hunting and, in particular, the exploitation of the larger herbivorous mammals that has received most attention and achieved the greatest significance in discussions of Mesolithic economics in Britain. The reasons for such an emphasis are probably legion, including the cultural bias discussed by Clarke (1976: 450-1), assumptions concerning the hunting role for microlithic forms, and, as discussed in previous sections, the paucity (real or otherwise) of evidence for alternative economic activities. It would be inappropriate to enter into a prolonged discussion of the historical and cultural background to the development of such an emphasis in British Mesolithic research. The importance traditionally given to hunting, however, and the degree to which it has, and continues to influence our understanding of Mesolithic economy, settlement, mobility and technology demands that the subject be dealt with in some detail. In the interests of clarity and structure the following discussion will concentrate upon the available direct evidence for Mesolithic hunting of larger herbivores and the various interpretations made concerning hunting activities. The implications for the broader aspects of Mesolithic settlement, mobility and technology will be dealt with in subsequent sections.

a) Archaeological evidence

As indicated in the introduction to this chapter the Mesolithic archaeological record has produced comparatively few sites that have preserved direct economic evidence. If we examine the available faunal evidence from Mesolithic occupation sites (table 3), purely on a presence/absence basis, there appears to be a remarkable consistency, with the exception of Elk (Alces alces), in the representation of Aurochs (Bos primigenius), Red deer (Cervus elaphus), Roe deer (Capreolus capreolus), Pig (Sus scrofa) and, less certainly, Horse (Equus sp.). The distribution of evidence is heavily biased towards lowland locations, with the exception of the small assemblage from Wetton Mill rockshelter (Kelly 1976). We might also note the evidence from two Peakland sites, Foxhole Cave (Bramwell 1973, 1977) and Dowel Cave (Bramwell 1959). At the former, remains of Red deer and Horse associated with 'broad-blade' (i.e. Earlier Mesolithic) flints have been reported (Bramwell 1973) although subsequent work has also revealed associations of Horse and Reindeer with Creswellian (late Upper Palaeolithic) tools (Bramwell 1977). Excavations at Dowel Cave revealed in layer 'g' split bones of large ungulates, interpreted as a late-glacial layer, and in layer 'e' a basal portion of a uniseral bone point (Earlier Mesolithic) associated with bones of pike and fowl as well as 'the same kinds of split bones ... as layer (g).' (Bramwell 1959: 100). Until the evidence from these two potentially important sites is published in more detail the associations, identifications and age(s) of these faunal assemblages will remain vague. It is enough, at this point, to note that the evidence for split bones is highly reminiscent of the behaviour Binford (1978a) noted in connection with marrow extraction for 'snacking' (363) at hunting stands as opposed to 'maintenance feeding' at hunting field camps (363).

Undoubtedly, of the sites which have produced faunal assemblages relating to Mesolithic subsistence it has been the evidence from Star Carr (Clark 1954, 1972, 1973;

Fraser and King 1954) that has received most attention and influenced our thinking on all aspects of Mesolithic economy, settlement and mobility. The importance of this site to Mesolithic research has been emphasized by the continued debate concerning the interpretation of the faunal evidence (Andresen et al. 1981; Caulfield 1978; Jacobi 1978a: 315-21; Pitts 1979). For the purposes of this discussion attention will be focussed upon the various perspectives which have been offered concerning the dietary and industrial evidence relating to faunal debris. The broader implications will be discussed at length in a subsequent section.

b) <u>Star Carr</u>

Excavated in the period between 1949-51 the site of Star Carr, located in the Vale of Pickering, produced an astounding array of organic materials relating to diet, technology and structures not normally preserved on Mesolithic sites in Britain. Situated on the northern edge of a former lake the site owed its remarkable preservation conditions to the waterlogged environment and peat deposits which now cover the eastern, lowermost areas of the Vale. Radiocarbon dates of 7538 ±350 b.c. (C - 353) and 7607 ±210 b.c. (Q - 14) on wood from the famous wooden 'platform' at the site clearly place the large Maglemosian lithic assemblage and faunal evidence in the middle of the eighth millenium b.c., and consequently provide us with a rare opportunity to examine a broad range of inorganic and organic debris relating to Earlier Mesolithic activity.

Following the original publications (Clark 1949, 1950, 1954; Fraser and King 1954; Walker and Godwin 1954) documenting the excavations, environmental and artefactual evidence Clark (1972) presented a re-analysis of the evidence which sought to place the activities represented within a behavioural interpretative framework. Central to Clark's interpretation was the combined evidence relating to faunal resource exploitation, and especially the various indicators of seasonality based upon interpretations of various aspects of the faunal assemblage.

c) Seasonality at Star Carr: Clark's model

Clark (1972: 22-3) placed considerable emphasis upon the evidence for seasonality in hunting claimed from analyses of the faunal remains of Red deer, Roe deer and Elk. Following the work of Fraser and King (1954: 93-5) Clark drew attention to the fact that of 106 Red deer antlers some 65 (61%) had been broken out of the skulls (unshed), whilst of some 26 stag crania and frontlets 21 (81%) still carried their antler stumps. These figures, it was argued (Clark op. cit.: 22; Fraser and King 1954: 93-5), indicated that,

> 'the main period of settlement coincided with the winter, during which the stags carried their antlers.'
>
> (Clark op. cit.: 22).

Additional evidence for seasonality was noted in several forms. The presence of some shed Red deer antler suggested that the site was 'occupied at least into early April, when antlers are normally discarded' (Clark op. cit.: 22), whilst the presence of numerous unshed Roe deer antlers led Clark to suggest occupation 'during at least part of April ... since roe deer do not discard their velvet until early in that month.' (22). The presence of unshed elk antlers suggested that these were obtained 'before early January' (Clark op. cit.: 22), since elk discard their antlers at that time.

The evidence for seasonality, as reviewed by Clark, led to the summary (fig. 18) emphasizing the evidence for Red deer procurement:

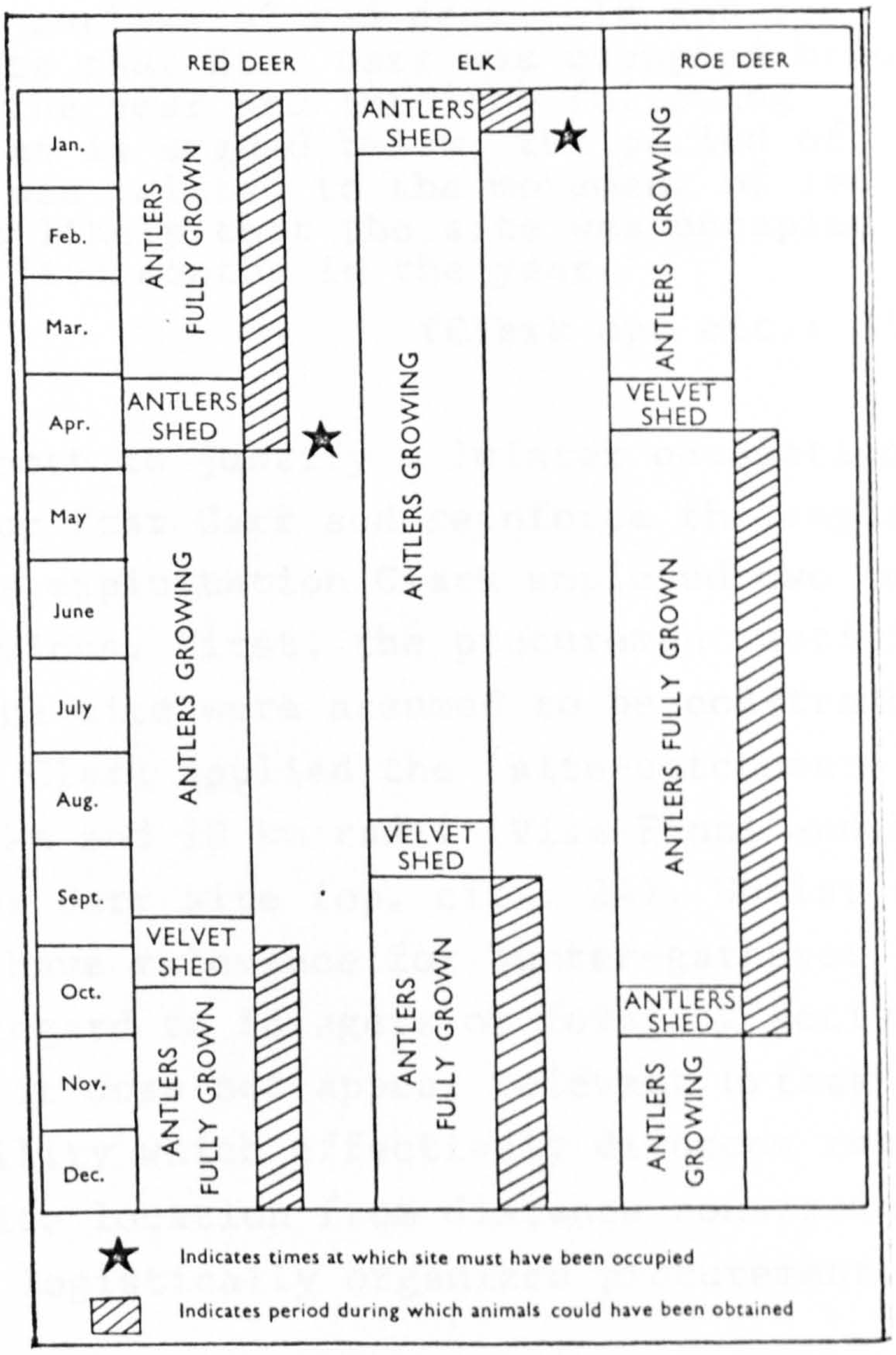

RED DEER
ELK
ROE DEER
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
ANTLERS FULLY GROWN
ANTLERS SHED
ANTLERS GROWING
VELVET SHED
ANTLERS FULLY GROWN
ANTLERS SHED
ANTLERS GROWING
VELVET SHED
ANTLERS FULLY GROWN
ANTLERS GROWING
VELVET SHED
ANTLERS FULLY GROWN
ANTLERS SHED
ANTLERS GROWING
Indicates times at which site must have been occupied
Indicates period during which animals could have been obtained

fig.18

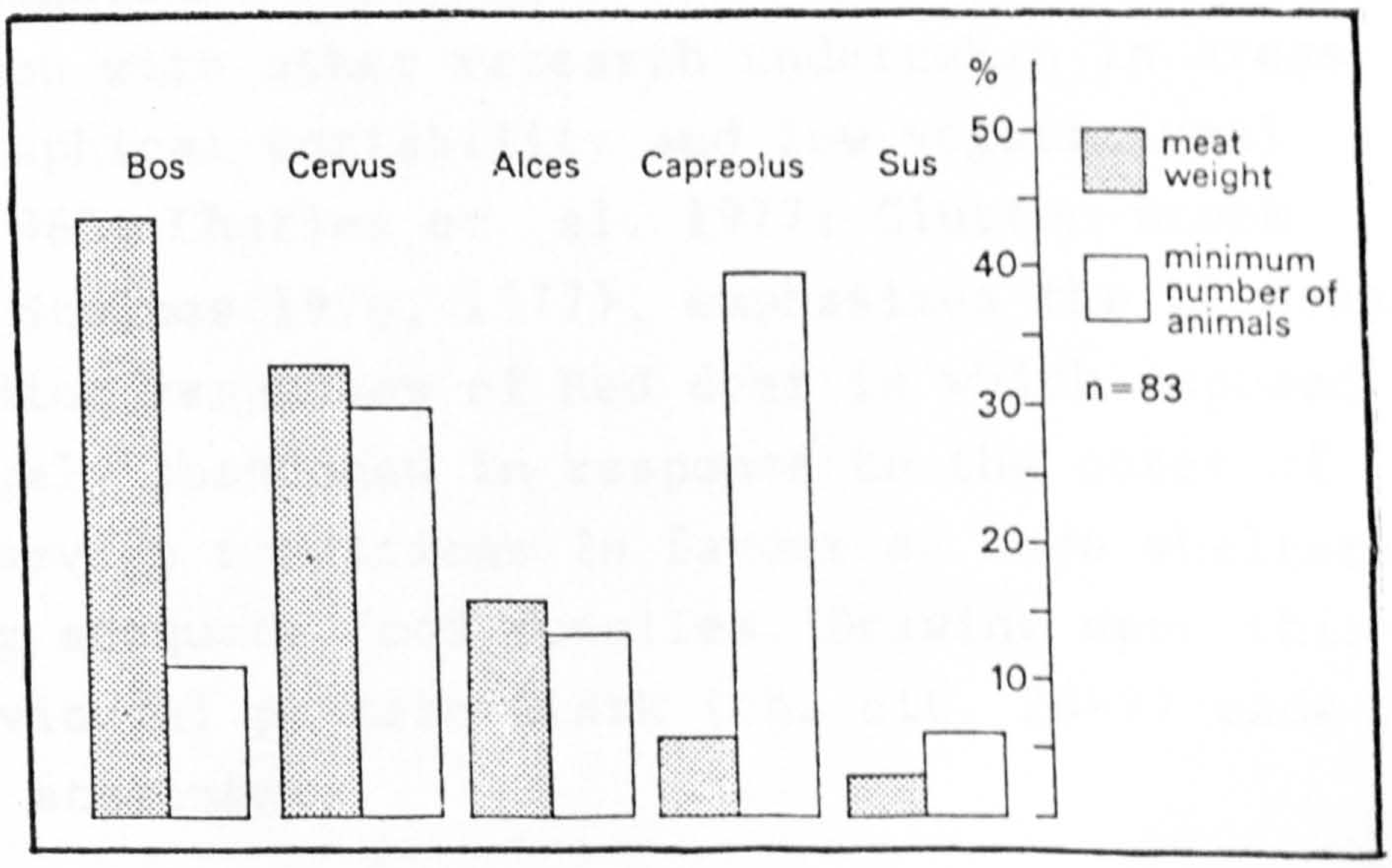

Bos
Cervus
Alces
Capreolus
Sus
%
50
40
30
20
10
meat weight
minimum number of animals
n = 83

fig.19

> 'analysis of antlers of red deer, elk and roe deer suggests that Star Carr was occupied before the end of the year and into the following April. If, as is argued below, the period of occupation was related to the movement of red deer, it is likely that the site was occupied for around five months in the year.'
>
> (Clark op. cit.: 23).

In seeking both to justify a 'winter occupation' interpretation for Star Carr and reinforce the emphasis given to Red deer exploitation Clark employed two separate argumentative devices. First, the procurement activities represented at the site were assumed to be constrained by distance, and Clark applied the 'site-catchment' concept using 5 km and 10 km radii (Vita-Finzi and Higgs 1970) to the Star Carr site (op. cit.: 24). Whilst such an approach may have relevance for hunter-gatherer site economics with regard to foragers or foraging activities (see chapter 2) it does not appear relevant to task-group procurement mobility which effectively divorces residence or field camp site location from distance constraints in connection with logistically organized procurement.

Second, Clark sought to relate the winter occupation theory to the migratory responses of herbivorous animals and, in particular, the observed behaviour of Red deer in the Scottish highlands (Darling 1969). Darling's (1969) study, in common with other research undertaken in areas of high topographical variability and low vegetational cover (Ahlén 1965; Charles et al. 1977; Clutton-Brock et al. 1982; Staines 1976, 1977), emphasizes the seasonal migratory/herding responses of Red deer in which exposed areas are largely abandoned in response to the onset of colder, more severe conditions in favour of more sheltered areas offering adequate food supplies. Drawing upon this observed behavioural pattern Clark (op. cit. 28-9) made the following statement:

> 'At a time when the northern temperate zone was affected by more pronounced seasonal variations than it is today, red deer and other animals directly dependent on vegetation must have responded to seasonal change by shifting their feeding grounds. In areas with any marked surface relief this would have taken the form of feeding on the highest ground during summer and sheltering on low ground during the winter .... In choosing winter quarters deer have regard to shelter and sunlight. This makes it easy to understand why the Vale of Pickering and especially the northern side should have been chosen by deer coming down from the moors.'.

This statement contains certain observations on herbivore migratory responses that are crucial to discussions of Mesolithic hunting strategies and these will be examined later. Having presented a resource model of summer-upland, winter-lowland movement Clark proceeded to employ one further behavioural observation on Red deer population dynamics:

> 'Another fact about red deer exceptionally relevant to Star Carr is that when they come down to their winter quarters or "yards" they do so in segregated groups, the adult stags separated from the hinds and immature animals.'
>
> (op. cit.: 29).

Clark noted the overwhelming preponderance of adult stags over femals and juveniles in the Star Carr faunal assemblage and concluded that,

> 'This can only mean that the Star Carr hunters were culling stags during the winter months.'
>
> (op. cit.: 29).

The picture presented by Clark emphasized the numerical predominance of Red deer in the faunal assemblage and depicted Star Carr as a predominantly winter occupation concerned first and foremost with the intensive exploitation of aggregated herds of Red deer stags occupying their winter yards in the Vale of Pickering.

This persuasive interpretation, and the implications which follow on with respect to upland Mesolithic activity, has dominated thinking on virtually every aspect of Mesolithic settlement and mobility since it was first published.

However, subsequent discussions and analyses of the faunal evidence from Star Carr, far from confirming Clark's (1972) model, have begun to highlight the shortcomings of the arguments employed in the winter-lowland, summer-upland model. In pursuing these new perspectives the work of Jacobi (1978a), Pitts (1979) and Andresen et al. (1981) will be employed. It will be seen that in addition to questioning the conclusions on seasonality of occupation put forward by Clark, the emphasis on Red deer hunting and the relationship of such hunting to the Star Carr site will be further doubted. None of what follows implies that Clark's work was inadequate - on the contrary, it emphasizes the utility of the documentation put together in connection with Star Carr and the quality of the work behind the documentation.

d) <u>Seasonality revisited</u>

In Clark's (1972) summary of the seasonality of Red deer, Roe deer and Elk procurement several important points were, if not overlooked, underemphasized. First, the presence of Red deer crania with shed antler, allowing for variability in antler growth rates, does indicate occupation 'at least' until early April. Second, the presence of Roe deer crania with unshed antler, rather than indicating occupation until 'at least' April, should be more appropriately restated as indicating exploitation between April and mid-October, when the antlers are shed. Third, the Elk antler, half of which were broken from the skulls (unshed) indicates occupation between mid-September and mid-January.

These observations stem directly from Clark's own analysis and do not take any account of the industrial utility of Red deer and Elk antler. If, however, we take into account the industrial usage of antler, as Pitts (1979) has done, several important points emerge. We know from the abundant evidence for use of groove and splinter techniques on Red deer antler at the site that antler was being subject to industrial usage. As Pitts (1979: 37) observes, there is a strong likelihood that all of the deer antler (excluding Roe) was deliberately collected and brought to the site for industrial purposes. The antler may have been collected over many months and transported to the site in anticipation of manufacturing needs, and may, therefore, have been transported considerable distances (Pitts op. cit.: 37). Support for this latter suggestion comes from evidence for the deliberate trimming and lightening of antler through the removal of unwanted sections (Fraser and King 1954: 80; Pitts op. cit.: 37).

It is, however, the comparison of antler with post-cranial elements that provides the clearest evidence for the selective introduction of antler onto the site. Jacobi (1978a: 316-7) has quantified the Red deer evidence in terms of the numbers of individuals represented by antler and crania (n = 61) and post-cranial remains (n = 25). Even allowing for juvenile and female crania, and crania with shed antler, the number of individuals represented by antler and cranial fragments (n = 51) far outweighs the post-cranial evidence. Quite clearly, therefore, Red deer antler was being selectively brought to the site, presumably for industrial purposes.

With regard to Elk, Pitts (1979) has pointed out that of fifteen loose antlers represented ten appear to be artefacts, including 'mattock-heads', which may well have been introduced onto the site as curated tools or parts of tools. The evidence for industrial use of Elk antler once again argues for care in considering the reasons for this material being on the site.

Pitts (1979: 39) has accordingly recalculated the proportions of the total herbivore faunal assemblage to allow for industrial antler usage. From his calculations it becomes clear (fig. 19) that the importance of Red deer in dietary terms can no longer be regarded as dominant. In terms of minimum numbers the most frequently represented species is Roe deer, and in terms of meat weight Aurochs is more important than Red deer or any other single species. As Pitts (op. cit.) notes,

> 'Thus the precarious dependence on a single main animal is replaced by a more balanced schedule in which no single species provides as much as half of the meat requirement.'
>
> (39).

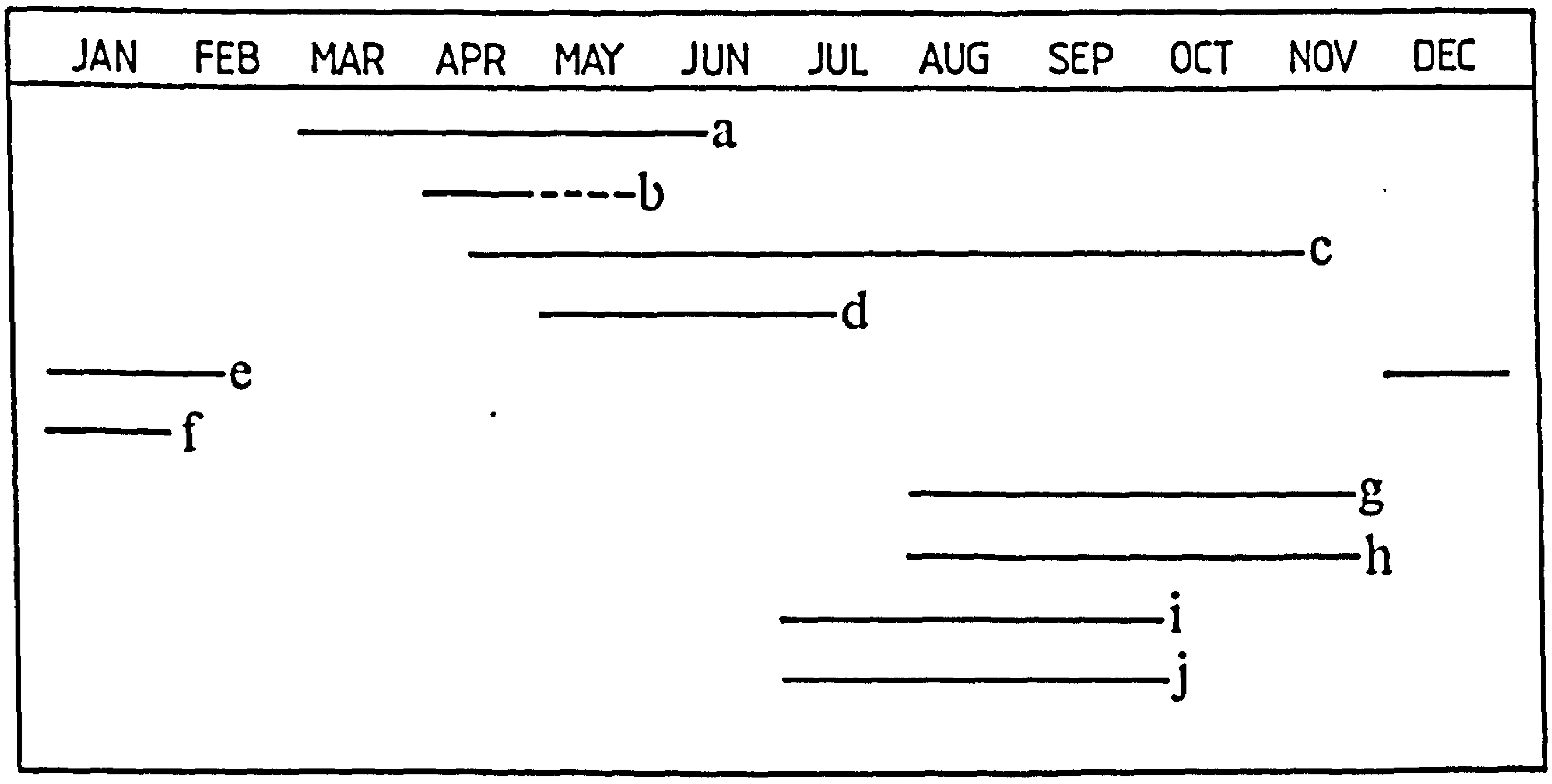
The resulting shift in perspectives on the dietary strategy represented in the Star Carr faunal assemblage, away from specialized Red deer hunting towards a more generalized strategy, has several major implications for discussions of seasonality, as well as for our understanding of the broader adaptive systems of the Earlier Mesolithic. As Pitts (1979: 38) has indicated, if we take account of the selective introduction of Red deer antler (only borne by males) for industrial purposes and exclude loose antler and worked crania from our calculations this leaves only six sexed crania - two female and four male - which hardly lends support to Clark's reasoning for the highly selective exploitation of stag herds occupying their winter yards. So too, the more generalized hunting strategy, with a numerical emphasis upon exploitation of non-herding Roe deer, casts further doubts upon the reasoning concerning Star Carr's locational qualities.

As if to emphasize the importance of activities undertaken away from Star Carr - possibly displaced by considerable distance - in shaping the Star Carr faunal assemblage, Jacobi (1978a: 316) has highlighted evidence which confirms the selective introduction of Red deer bones (and by implication, cuts of meat) following procurement and butchery at other locations. Various elements of the Red deer post-cranial skeletons are underrepresented - vertebrae, pelvic bones and portions of forelimbs -

indicating field butchery and transportation of selected cuts to Star Carr from other locations.

Given the increasing doubts concerning the nature of the evidence and character of the occupation at Star Carr it seems appropriate to consider the range of seasonality indicators proposed by various authors which remain (fig. 20). Of the indicators included, the evidence for reedswamp growth at the time of occupation (Andresen et al. 1981; Walker and Godwin 1954: 67), bracket fungus collection (Andresen et al. 1981; Clark 1950: 124) and the presence of bones of white stork (Andresen et al. 1981; Fraser and King 1950: 128) may be difficult to directly associate with with deliberate collection or activity on site. The remaining indicators, however, clearly argue for occupation at various seasons of the year including winter. It is worth noting that given the numerical importance and demonstrably non-industrial usage of Roe deer remains the evidence for occupation during spring and/or summer is as, if not more, persuasive or significant as are the indicators of winter occupancy. We may conclude, therefore, that Clark's model of winter occupancy of Star Carr in connection with specialized Red deer procurement must be abandoned in favour of a more complex, and possibly diverse set of functional and seasonal interpretations of the activity represented. As will become clear, such a change in perspective carries far-reaching implications for our approach to understanding Earlier Mesolithic adaptations.

Before returning to consider the faunal evidence from Mesolithic sites in general it is appropriate to briefly note some of the perspectives that have been put forward concerning the function of the Star Carr site. Clark (1972: 21) noted that there was some evidence for two chronologically distinct phases of occupation at Star Carr. Beyond this, Andresen et al. (1981) have suggested that the spatial organization of remains and features (such as hearths) is probably indicative of a series of repeated occupations, each of relatively short duration. In their account of the Star Carr site Andresen et al. (1981) have favoured the interpretation of the activity represented as being primarily that of a hunting location connected with 'intercept' strategies (43) for procuring



Star Carr: non-industrial seasonality

a) Roe deer antlers in velvet - March to early June (Fraser and King 1950 : 125).

b) 4 Red deer crania with shed antler - April to early May (Fraser and King 1954 : 80).

c) 8 Roe deer crania with antlers - May to early November (Fraser and King 1954 : 75).

d) Young of Elk and Red deer - May to early July (Noe-Nygaard 1975).

e) Healed lesions on Elk and Red deer scapulae - December to february (Noe-Nygaard 1975).

f) 2 Elk crania with shed antler - January (Fraser and King 1954 : 75).

g) Reedswamp growth - late summer or autumn (Walker and Godwin 1954 : 67).

h) Bracket fungus collection - late summer or autumn (Clark 1950: 124).

i) Bones of white Stork - summer (Clark 1954: 70).

j) Birch bark collection for resin - summer (Clark 1954: 166).

fig. 20

deer. Without entering into a detailed discussion of their reasoning it is interesting that emphasis is placed on accounting for the diverse lithic and non-lithic technological activity through reference to behaviour at hunting stands and blinds from Australian (i.e. forager) contexts. I would argue that the industrial evidence for anticipatory manufacture of antler splinters and their removal to other locations for conversion into finished barbed points (Andresen et al. 1981: 39; Jacobi 1978a: 318-21) combined with the presence of a wide range of tool forms including axes and axe-resharpening flakes, scrapers, burins, microliths, awls and mattock-heads, as well as evidence for tree felling, birch bark rolls (for resin?) and structures (wooden platform) does not obviously conform with the predictions for hunting-stand 'boredom reducers' (Binford 1978a) in the more relevant context of a logistically organized adaptation.

Similarly, the interesting account given by Pitts (1979) of Star Carr as a hide processing location, whilst perhaps accounting for some of the activity represented, does not appear to be a sufficiently broad explanation for the diversity of activity represented, and the range of seasonal indicators for the occupancy of the site (Andresen et al. 1981: 41). Particularly telling, in this respect, is Pitts' (1979) own observation that,

> 'If it is accepted that the excavated remains from Star Carr derive from a specialized activity zone within a larger settlement, then we have to admit that we are ill-equipped to attempt a detailed interpretation of the complete site.'
>
> (40).

I would go further, and suggest that as long as the interpretation of site function at Star Carr remains geared solely to viewing the evidence in isolation from the broader, regional archaeological record then such interpretations will always be a matter of personal emphasis and bias. What is readily apparent is that no single, mono-functional interpretation of this complex site will ever adequately account for the probable variability in site function represented. We could do worse than to bear in mind Binford's (1982) observation that,

> 'In a logistically organized system of exploitation (collectors), different places in the habitat of a single system are used differentially and occupied for different purposes .... The economic potential of ... fixed places within the habitat changes with any change in the placement of the residential hub.'
>
> (18: my emphasis).

I would tentatively conclude, therefore, that Star Carr may probably be best understood as a location, visited at various times of the year, whose function in the context of a broader adaptational system, varied from occupation to occupation.

e) Mesolithic hunting: beyond Star Carr

The emphasis given to Red deer in Mesolithic hunting strategies (Clark 1972; Jarman 1972) no longer appears appropriate, in dietary terms, to the Star Carr evidence (see above) or, for that matter, the faunal record for British Mesolithic sites in general. As Simmons et al. (1981) have shown, using Jarman's (1972) method for calculating the importance of species, Red deer do not appear as the dominant species for either Earlier or Later Mesolithic faunal assemblages (118). On the contrary, the evidence appears to indicate the generalized nature of hunting, with a balanced representation of the major herbivores.

In very general terms discussions of the role of hunting in Mesolithic subsistence have tended to emphasize two connected dimensions of herbivore behaviour:

(1) The spatial and temporal behavioural characteristics of individual species,

and

(2) The generalized responses of herbivore populations to environmental variability.

	AUROCHS	RED DEER	ROE DEER	PIG	HORSE	ELK	
THATCHAM 3	*	*	*	*		*	
THATCHAM 5		*	*	*			
THATCHAM 1	*	*	*	*	*		
FLIXTON 1	*	*				*	
WAWCOTT 12					?		
STAR CARR	*	*	*	*		*	EARLIER MESOLITHIC
WAWCOTT 30	*	*	*	*		*	
THATCHAM 2	*	*	*		?	*	
THATCHAM 4		*	*			*	
WAWCOTT 15	*	*	*	*			
WETTON MILL	*	*	*	*			
GREENHAM		*		*			
FOXHOLE CAVE		*			*		
MOTHER GRUNDY'S C/B					*		UNCERTAIN
C	*				*		
WEST HARTLEPOOL		*	*	*			
WESTWARD HO!	*	*	*	*			
BLASHENWELL	*	*	*	*			
MORTON TAYPORT	*	*	*	*			LATER MESOLITHIC
WAWCOTT 23	*	*			*		
KING ARTHURS	*	*		*	*		
PRESTATYN	*			*			

Presence / Absence of Large Terrestrial Mammals

* = PRESENT. ? = UNCERTAIN. = ABSENT.

table. 3

In considering these dimensions it is important to maintain a distinction between the generalized behavioural characteristics of individual species, and the possible effects of environmental variables upon those characteristics in order that we can view herbivore behaviour as responsive, both qualitatively and quantitatively, to long-term trends in the environment. It is not enough, for example, to seek to view Red deer behaviour as unfalteringly based upon major seasonal migratory responses with highly defined yarding behaviour during winter, since this pattern will vary according to the degree of adaptational selective pressure operating for migratory versus non-migratory responses (see Grigson 1978: 53). Thus, whilst we may characterize Red deer behaviour as being gregarious and seasonally migratory in comparison with Roe deer this does not imply that under all circumstances Red deer aggregate in large numbers during winter or that such aggregations follow long migrations. It must be remembered that studies of Red deer behaviour in the Scottish highlands and other areas of high altitudinal variability and low vegetational cover are dealing with adaptations to environments where the onset of colder conditions will, by virtue of poor cover, oblige populations to seek the shelter of low-lying areas. On small islands, such as Rhum, the number of suitable yarding areas is limited. In contrast, the forested environment of mainland Britain will have offered a greater degree of cover, food resources, and locational choices for over-wintering.

If, therefore, we accept that distributional adjustments in herbivore populations were not as pronounced in Mesolithic contexts as studies such as Darling's (1969) reveal, and we view spatial adjustment as a dynamic adaptational response, we must ask to what extent the degree of spatial adjustment varied within the Mesolithic period. Our answer to this question could prove most significant in the discussion of Mesolithic exploitation since we can expect the hunting strategies of Mesolithic groups to have been, in part, dependent upon the spatial and temporal population dynamics of target resources.

f) Resource behaviour

i) Red deer (*Cervus elaphus*)

As already discussed, the behaviour of Red deer is frequently characterized as exhibiting a tendency to abandon exposed areas with the onset of adverse conditions in favour of sheltered locations offering suitable winter feeding conditions. Such seasonal adjustments may be most pronounced in areas of high altitudinal variability, and may entail movement off exposed ground into river valleys and more heavily developed vegetation, as opposed to the complete abandonment of upland regions. Whilst much has been made of the role of insect irritation during spring and summer in promoting the movement of animals away from low-lying areas and leading to upland summer dispersal (Jacobi 1978b: 301) we cannot be sure as to the degree to which this factor influenced summer dispersal patterns. Certainly, it seems very unlikely that summer saw the wholesale abandonment of the extensive low-lying regions of Britain. Rather, we might envisage the summer repopulation of higher ground as being relevant to deer populations in the general upland region. Such a movement would clearly be relevant *if* we assume that the onset of colder conditions had brought about an abandonment of higher ground in the first place.

In the context of Mesolithic environmental developments two factors may prove particularly relevant to Red deer behaviour, and the consequences for exploitation patterns. As discussed in the previous chapter, the Earlier Mesolithic saw very pronounced seasonal extremes in temperatures, with comparatively short autumnal and spring seasons. We might suggest that any migratory shifts away from exposed upland localities would have begun in anticipation of severe winter conditions and resulted in a relatively defined period, during the short autumnal season, when animals moved into the shelter of leeward slopes and valleys. Further movement down the valleys may have varied according to the degree of snowfall, the availability of food, and the severity of late autumnal/early winter temperatures. Similarly, the spring return migration will have probably occurred within a reasonably short period dependent upon these same variables.

If the migratory responses of Red deer were limited during the Earlier Mesolithic then the effects of the rapid climatic amelioration, with its attendant reduction in seasonal temperature ranges, extended autumnal and spring seasons, and increasing quantities of understorey vegetation must have been reflected in the reduction of selective pressure for such migrations. Any migratory responses will have been extended, in terms of timing, over the longer autumnal and spring seasons thereby reducing the cohesiveness of such responses. In low-lying areas it seems increasingly unlikely that the milder winters would have demanded pronounced population adjustments. As Grigson (1978) has noted with respect to the behaviour of American Red deer (Cervus elaphus canadensis),

> 'The American red deer is migratory and forms large herds in at least some of its range; this seems to be an adaptation to the continentality of the North American climate and to the fact that it is less tied to woodland than its European relative.'
>
> (53).

A change from the more 'continental' climatic regime of the Earlier Mesolithic to the 'oceanic' conditions experienced during the Later Mesolithic may, therefore, have brought a shift in Red deer behaviour which saw a decreasing role for regularized seasonal migrations and, in its place, a more stable temporal and spatial population distribution, with lower levels of aggregation.

ii) Roe deer (Capreolus capreolus)

Unlike Red deer the behaviour of Roe deer does not generally incorporate seasonal herding behaviour or migratory responses involving the abandonment of one area in favour of another. Roe deer tend to adjust to adverse conditions through movement within their summer territories.

Although numbers of Roe may aggregate towards the end of winter this is usually a response to limited browse (Prior 1968: 32). Generally speaking the territoriality of Roe deer during spring and summer, combined with the tendency to migrate within those territories ensures that within woodland environments Roe populations maintain a relative stability in spatial distribution.
As noted by Prior (op. cit.),

> 'Territories ... are likely to take in all established woodland ... while winter feeding grounds are restricted to part of the acreage. In this type of forest (deciduous woodland), movement between these two categories covers, on average, considerably less than one mile, though individuals may wander much further than this.'
>
> (33).

Interestingly, however, Prior (op. cit.) also noted that during the exceptionally severe winter of 1962-63 Roe deer withdrew from normal feeding grounds to south facing slopes and more sheltered areas offering browse (39). As a result, the severe conditions produced localized concentrations similar to the yarding behaviour of Red deer. This case illustrates how migration, as an adaptive strategy, will vary according to the selective pressures being exerted.

The more seasonal and rigorous conditions of the Pre-Boreal and Boreal must have exerted some influence on Roe deer migratory responses but it is not possible to determine to what extent such responses would have involved winter aggregations or yarding. More certainly, the improving climate, increasing deciduous component and understorey vegetation of the Late Boreal must have favoured the establishment of defined, stable territories with only minor adjustments during winter.

iii) Elk (Alces alces)

The largest of the cervids Elk (or Moose), unlike Red deer, tend to remain in family groups throughout the year.

Their capacity to incorporate a broad range of shrubs, herbs, aquatic plants, bark and twigs into their diet enables them to maintain a relatively stable population distribution even under severe conditions (Chaplin 1975: 41). As discussed previously, it appears as though Elk disappeared from the forest fauna of mainland Britain during the Boreal or early in the Late Boreal (Grigson 1978: 54), although reasons for this apparent extinction still remain open to debate.

iv) Aurochs (Bos primigenius)

Discussions of the behaviour and habitat preferences of the Aurochs have been heavily dependent upon analogies with wild cattle and, in particular, the observed behaviour of the feral Chillingham herd (Grigson 1973, 1978). It is far from clear to what extent Aurochs may have been engaged in migratory or spatial adjustment responses (i.e. P. Evans 1975), although it is thought that the dominance of individual bulls over herds or family groups (Grigson 1978: 54) may have caused young adult bulls to remain separate from such groups. What is more certain, the Aurochs appears to have coped with a wide range of habitats and was probably both a browser and grazer of vegetation (Grigson 1978: 54). The numerous discoveries of Bos remains both in archaeological site faunal assemblages and as isolated finds in peat deposits above 2000 ft. OD is ample testimony to the abundance of this species during the early post-glacial of mainland Britain (Grigson op. cit.).

If migration was a feature of Aurochs populations during the Pre-Boreal and Boreal then, as with deer populations, it would seem likely that the progressive amelioration of climate and development of mixed deciduous forest cover during the Late Boreal - Early Atlantic periods would have encouraged a reduction in those strategies in favour of non-migratory responses.

v) Wild pig (Sus scrofa)

Wild pig or Boar tend to be closely associated with moist woodland (Heck 1950), avoiding areas of higher altitude, possibly in connection with high snow cover (Jochim 1976: 103). Feeding on nuts, roots, herbs and a range of non-vegetable resources including worms and larvae Boar tend to favour deciduous woodlands as opposed to coniferous forests and open ground although this preference is not absolute and would be reflected in higher population densities in the former.

For most of the year the males remain solitary, joining female groups during the rut in November and December (Jochim op. cit.: 106). Consequently, group sizes vary throughout the year, with mobility being at its greatest during autumn when they may move considerable distances foraging on nut concentrations.

Although it is clear that Boar was well represented in the forests of the Pre-Boreal and Boreal it also seems likely that the development of mixed deciduous woodland during the Late Boreal - Atlantic periods would have favoured Boar and possibly encouraged higher population densities. Whilst there are no clear patterns of migration in response to climatic conditions it does seem reasonable to suggest that winter, when mobility is at its lowest, was less of a significant constraint during the Later Mesolithic than in the Earlier period.

vi) Horse (Equus sp.)

Little is known of the status of Horse populations in the Mesolithic environment and some doubt has been cast over the Mesolithic age of several finds of Horse within Mesolithic faunal assemblages (Grigson 1978: 54). However, on present evidence it does appear that Horse was present - if not in large numbers - as testified by remains from the Later Mesolithic sites of King Arthur's cave (Taylor 1927), Wawcott 23 (Grigson 1978: 52), and the dated level C at Mother Grundy's Parlour (Campbell 1969).

The survival of Horse populations into the Mesolithic has been related to the persistence of relatively open areas, but, as noted by Grigson (1978: 54) they would have faced considerable difficulties during the Atlantic period when the deciduous forest environment developed. It does appear, however, that of the various species considered here the dietary contribution made by Horse exploitation was relatively minor.

vii) Summary

It has been argued that, concerning the behaviour of the major herbivore species exploited by Mesolithic groups, the relationship between distributional adjustments in populations and environmental constraints must be considered both in terms of the generalized responses of individual species and with regard to changes in the environment. Two points have been stressed:

(1) Migration responses to adverse conditions may not have been as pronounced as previously thought. During the periods when Britain's climate was more 'continental' in character the areas most likely to have witnessed migratory adjustments would have been those with greatest altitudinal variability and, arguably, least vegetational cover.

(2) The development of a more 'oceanic' climatic regime and the establishment of a mixed deciduous cover with greater understorey vegetation would have seen a shift away from the selective advantages of migratory responses towards more sedentary strategies. Any migratory behaviour would have been subject to greater temporal variation in its initiation and scale.

4) Mesolithic hunting strategies

Given the central importance achieved by Clark's (1972) model of Earlier Mesolithic Red deer specialization in general discussions of the period it is not surprising that we find that perspectives on Mesolithic terrestrial hunting strategies repeatedly emphasize the role of Red deer exploitation, and especially the key role, identified by Clark, of exploitation of aggregated Red deer herds during winter.

> 'In fact, reasons will be given below for thinking that the hunting of at least some of these animals may have been appreciably easier and more productive during the winter months than at other times of the year. Striking empirical support for the importance of hunting in the winter activities of at least one Mesolithic community is of course available from the site of Star Carr.'
>
> (Mellars 1976a: 381: my emphasis),

and, again,

> 'it will be apparent that in many inland areas of Britain the bulk of the food supply throughout the winter season is likely to have been provided by the hunting of large mammals.' (Mellars 1976a: 381).

As if to emphasize the importance of Red deer hunting in Mesolithic adaptations the rationale of Clark's model is extended to the entire seasonal round:

> 'both the upland and lowland sites may have been occupied by the same social groups in the course of regular seasonal movements based on the migrations of red deer.'
>
> (Mellars 1974: 84),

and, once more,

> 'The seasonal round of the Star Carr hunters was possibly controlled by the movements of the red deer, and the sites of their summer/early autumn activities should coincide with that animal's known preference for upland grazing at that time of year.'
>
> (Morrison 1980: 122)

A number of important points arise from these perspectives on Mesolithic hunting. Whilst the exploitation of aggregated resources may prove 'easier and more productive' than the exploitation of dispersed resources the evidence from Star Carr, in the light of re-analysis, does not provide unequivocal empirical support for the operation of such strategies in the site's vicinity. Given the arguments on migration discussed in the previous section it is far from certain that the winter yarding behaviour of Red deer during the Earlier Mesolithic would have produced large and spatially predictable aggregations in low-lying areas of Britain. Even if such aggregations did occur, and remember that the Star Carr analysis no longer directly supports this theory, it would seem to be a remarkably risk-laden strategy to exploit the key over-wintering resource at precisely the time when such resources were most needed for immediate consumption. Any failure or short-fall in such a strategy would expose the entire community to the spectre of starvation, with the minimum of time for adopting an alternative strategy.

With regard to the annual round, the view that upland areas were visited and exploited during summer because Red deer populations had dispersed to those upland regions does not explain why the attractions of exploiting a single, dispersed species were greater than remaining in more low-lying areas and adopting a more generalized strategy incorporating a range of large herbivore species as well as a range of alternative dietary inputs including plant-foods, fishing, fowling etc.. Once again, why should a group engage in a risk-laden specialist strategy when alternative, more generalized options were available? The Star Carr evidence indicates that a more generalized hunting strategy was pursued, and the Roe deer evidence clearly points to lowland hunting of largely non-migratory resources during the spring and/or summer. Similarly, the presence of Elk and Red deer calf bones at Star Carr clearly indicates hunting during late spring and/or early summer. Furthermore, the range of species represented at other Mesolithic sites, both Earlier and Later, indicates generalized as opposed to specialized hunting strategies. It would seem highly inappropriate for generalized hunters to structure their seasonal mobility during summer around the movement of a single species.

At this point, however, it is important to consider two separate aspects of our faunal evidence. First, almost all of the faunal evidence relating to Earlier Mesolithic hunting strategies derives from lowland sites. Secondly, and crucial to our discussion, whilst the non-industrial, post-cranial evidence from Star Carr indicates a generalized hunting strategy of the 106 Red deer antlers some 61% were unshed. Whilst Pitts (1979: 37) has argued that the antler could have been gathered at any time of the year this cannot apply to unshed Red deer antler which must have been procured through hunting at some point between mid-October and early April - the time when the fully grown antlers are being carried. This implies that at some time during autumn or winter these Red deer were being hunted, their antlers stored, and subsequently lightened and transported to sites for further industrial processing. Indeed, if one accepts the arguments of Jacobi (1978b) for the manufacture of the final barbed points being undertaken at another site subsequent to the production of splinters (see Andresen et al. 1981: 39) then we gain a clear impression of a highly structured, anticipatory procurement and manufacturing process. The questions arise, at what point of the year and in which locality were these Red deer being procured? We can confidently rule out spring and summer as we know that the unshed antler must have been procured during autumn and/or winter. Whilst it has been generally acknowledged that it is not abundance but distributional characteristics (Mellars 1976a: 384) that influence hunting strategies too little emphasis has been placed upon two key dimensions of large mammal behaviour that are crucial to determining hunting strategy and the role of such strategies within hunter-gatherer economies: predictability and timing.

To help us understand the influence of predictability and timing in determining hunting strategies and the role of such strategies we can briefly examine the detailed accounts of Nunamiut behaviour provided by Binford (1978a). Nunamiut subsistence represents an adaptation to a highly specialized environment in which species dominance has been achieved by Caribou (Rangifer tarandus). Some 70% of the total dietary requirement is obtained during the brief autumnal and spring migrations of Caribou: in spring the Caribou move northward, from the flat timberlands, through the narrow valleys of the Brooks mountains and out onto the northern tundra, where they disperse to feed and reproduce during late spring and summer. In autumn the Caribou return, through the mountain ranges, to the timberlands where they over-winter. Utilizing their knowledge of the landscape and the behaviour of Caribou the Nunamiut employ a range of tactics and strategies to intercept the migrating herds when they are either in or just moving out from the valleys of the Brooks range. The autumn period is crucial for providing sufficient stores of meat for over-wintering, whilst the spring hunt provides meat for replenishing the depleted stores from the autumn hunting which provides a reliable source of food during spring through to summer. Remember, the specialized nature of the central Alaskan environment offers relatively few alternative options as the growing season is short and the species diversity is low. Furthermore, the dispersion of animals during summer across large tracts of largely undifferentiated landscape obliges the Nunamiut to adopt a strategy of hunting which differs from that employed during autumn and spring. These contrasting strategies have been named intercept (Binford op. cit.: 235, 350) and encounter (Binford op. cit.: 85).

Encounter strategies arise in contexts where the precise location of game cannot be accurately anticipated and when the dispersion of game is high. Hunters must spend considerable time locating animals with no guarantee of hunting success. As Binford states,

> 'Summer hunting is encounter hunting. Animals killed are rarely aggregated and they are few. The number of animals actually killed during summer is far below the number taken in fall and spring.'
>
> (op. cit.: 85).

It is interesting to note that outside of the periods devoted to intercept hunting in connection with the autumnal and spring Caribou migrations the use of encounter strategies is associated with both Caribou and Sheep hunting (Binford op. cit.: 278, 406) as well as some fishing activity. In other words, the periods of intercept hunting are specialized Caribou procurement periods and the periods associated with encounter strategies see a shift towards more generalized food procurement activities.

The details of intercept hunting are informative with regard to the responsive nature of such strategies in capitalizing upon the relationships between Caribou movement and details of the physical environment. During the autumnal migration, for example, Binford noted that hunting stands varied according to their specific characteristics: some being suitable for close range shooting, others less so; some being used for visual monitoring of game movement, others not being so suited etc. (359). The unifying element in these intercept sites was the anticipatory nature of the hunting strategy - the assurance that concentrations of animals would appear in a defined area within a given time period.

In a number of instances intercept hunting was associated with 'drives' in which the Caribou were moved closer to a series of hunting stands in order to reduce the shooting distance (235). The need to take sufficient animals in the limited time available promoted various carefully planned techniques. During autumnal migrations hunters would disguise themselves, using skins and antlers, and lie in the path of the migration:

> 'They could then stand up in the midst of the ... herd and fire arrows until they were out of projectiles or until they had simply killed enough. The silence of the bow and arrow ensured that the animals would not spook and run away ....'
>
> (392).

The success of intercept hunting can be seen to be dependent upon a number of factors; first, the knowledge that game would occur in concentrations within a given time in a given area; secondly, that the movement of game could be anticipated or controlled; thirdly, that the technology associated with procurement was adequately prepared in anticipation of killing sufficient numbers of animals. To these we might add the organizational demands associated with processing of meat, which are greatest after the spring migration hunt when the meat must be dried quickly before it starts to go off (493).

Archaeologically, the contrasting characteristics and contexts of application noted for intercept and encounter hunting strategies carry a series of important implications which will be discussed later. In terms of Mesolithic faunal assemblages the general impression of generalized hunting patterns suggests that much of the available evidence appears to indicate the predominance of non-specialized, encounter strategies in operation. The evidence from Star Carr, however, might be taken to indicate that in addition to a more generalized strategy operating in the vicinity of Star Carr there were inputs, in the form of large numbers of unshed Red deer antler, from a more specialized strategy undertaken at some location during the autumn and/or winter periods. If one accepts the evidence for highly structured, anticipatory behaviour in the collection, lightening, transportation, splinter manufacture, further transportation, and final manufacture of antler barbed points then the initial procurement of the antler need not have been closely associated, in time or space, with the activity at Star Carr.

Given the arguments put forward previously regarding the level of lowland aggregation for Red deer during winter, and the high risk associated with a specialized hunting strategy as the means of providing crucial food resources at the very time when such resources are most needed (i.e. winter) it would seem that for specialized Red deer hunting to provide a secure input of resources for over-wintering the most appropriate period for such a strategy would be during autumn, and not winter.

The second question that was asked, 'at what locality would specialized Red deer procurement be best undertaken', brings us back to the perspectives on Red deer migration and the constraints which determine the success of an intercept strategy of hunting. It has been argued that during the Pre-Boreal and Boreal periods the short duration of the autumnal and spring seasons, combined with the pronounced seasonality of climatic conditions, would have produced relatively defined and cohesive responses in species such as Red deer. It was further argued that the degree of regularity, scale and temporal cohesion for such seasonal migratory adjustments would have been greatest in the upland regions where altitudinal variability and reduced levels of cover would have promoted migratory versus non-migratory strategies.

In terms of the constraints for applying intercept strategies in connection with securing sufficient resources for over-wintering the first two factors - the ability to anticipate the timing and location of game concentrations, and the ability to anticipate and/or control game movement - would suggest that upland valleys during the periods when game would be known to be moving into such areas offer the optimal conditions for applying such strategies. Given that some 61% of the Red deer antler at Star Carr must have been procured before spring the obvious implications of these considerations lead us to the suggestion that specialized Red deer intercept strategies were employed during the autumn in connection with the anticipated occurrence of game within the sheltered confines of the upland valleys. Such a strategy would enable the procurement of surplus food supplies for over-wintering well in advance of the period when such supplies would be required. Consequently, the anticipatory procurement of winter food supplies would represent a far less risk-laden strategy than the alternative - of remaining dependent upon direct inputs from winter hunting.

Here, therefore, is a model of Earlier Mesolithic hunting strategy which appears to provide a more appropriate account - both with regards to the available faunal evidence and in general adaptational terms - of temporal structuring in subsistence behaviour. In place of Clark's mono-dimensional view of Red deer specialization we now have a model of seasonal differentiation in hunting strategies, with spring and summer being devoted to generalized strategies in the lowlands and autumn seeing the focus shift to the uplands for specialized intercept hunting of Red deer. Winter, by implication, was a period of considerably reduced food procurement activity with the emphasis being upon consumption of stored meat from the autumn. Given the intense and prolonged cold of the Pre-Boreal and Boreal winters it seems reasonable to suggest that the principal activities of this period would have been fuel collection and a range of residence-based craft activities. Logistical mobility during winter could have been largely confined to the incorporation of cached resources into the winter settlement, with only a very small input of freshly procured food resources (limited hunting, ice-fishing, fowling etc.). Such a model would account for the introduction of transported Red deer antler into lowland settlements for industrial purposes and for the disproportionate representation of certain post-cranial elements of Red deer skeletons. The previously noted evidence for hunting stand 'snacking' behaviour at upland valley sites would fit well into such a model.

Clearly, the model of Earlier Mesolithic hunting scheduling being proposed differs radically from the Clark model. Given the degree in which the Clark model has influenced discussions and interpretations of virtually all aspects of mainland Mesolithic behaviour this reappraisal must convey fundamental implications for all aspects of Mesolithic settlement, mobility and technology. It is, however, necessary to emphasize that both Clark's model and the model proposed here are only relevant to the Earlier Mesolithic. The evidence and arguments from suggested patterns of resource behaviour are only relevant to the Pre-Boreal and Boreal periods. From the discussions of Mesolithic environment, chronology and resource behaviour it is evident that the transition to Later Mesolithic technologies occurred during a period of relatively rapid and significant changes in the environmental landscape. Whilst there has been a tendency to incorporate the Clark model in accounting for Later Mesolithic archaeological patterning I feel that, at best, this represents an over-extension of the model's utility, and, at worst, the sort of uncritical analysis which effectively denies us the opportunity for understanding the differences between Earlier and Later Mesolithic behaviour.

5) Later Mesolithic hunting strategy

The problems of inadequate faunal assemblages in the Mesolithic archaeological record are particularly pronounced for the Later Mesolithic period. Once again, virtually all of the direct evidence comes from lowland and, in particular, coastal locations. Of those sites which have produced faunal assemblages directly referable to mainland hunting it is the evidence from Morton Tayport B (Coles 1971) that provides us with the best documented sample. In keeping with the general impression of generalized hunting strategies the Morton Tayport B evidence indicates a balanced representation, in minimum numbers of individuals, of Red deer (n = 2), Roe deer (n = 1), Aurochs (n = 2) and Boar (n = 1). It is interesting to note that, in contrast with the Earlier Mesolithic, Later Mesolithic assemblages have thus far failed to produce clear evidence of intensive industrial processing of antler. In one sense, this is not surprising since it would appear that apart from the Obanian sites and stray finds from Cumstoun in Kirkcudbrightshire, Shewalton in Ayrshire (Lacaille 1954) and Whitburn, County Durham (Mellars 1970), no items of projectile technology made of antler have been recovered from Later Mesolithic contexts. This does, of course, raise the problem of why the widespread usage of antler projectiles appears to end with the transition to Later Mesolithic technologies. This question will be addressed at a later point.

In terms of faunal evidence, therefore, the impression is given of the Later Mesolithic being dominated by generalist hunting strategies. In view of the discussion of the likely impact of the environmental changes which were associated with the insularization and climatic amelioration of the British mainland upon the behavioural responses of large herbivores the absence of evidence for specialized strategies might be best understood as reflecting the disappearance of the conditions which enable such specialized strategies to be employed beneficially.

It has been argued that the success of intercept, specialized strategies is dependent upon the ability to predict the timing and location of game concentrations and upon the capacity to anticipate and/or control the movement of such game concentrations. It has been further argued that the development of increasingly 'oceanic' conditions, with the attendant reduction of seasonal extremes in conditions, extended autumnal and spring seasons, increased deciduous and understory vegetation of the Late Boreal - Early Atlantic periods would have promoted the more widespread adoption of non-migratory, dispersed adaptations. Any migratory responses during this period, it has been suggested, would have been subject to higher temporal and spatial variability in timing and scale. As a consequence it may be that the Later Mesolithic offered few opportunities for employing specialized intercept strategies with respect to herbivore exploitation. If this assessment is broadly correct then the crucial difference between the subsistence hunting schedules of the Earlier and Later Mesolithic would have been in connection with the procurement and subsistence strategies for solving the problems of over-wintering. Whereas the Earlier Mesolithic saw the use of anticipatory specialized intercept strategies during autumn in order to provide stored foods for over-wintering such an option may not have been available during the Later Mesolithic. In other words, Later Mesolithic over-wintering strategies may have demanded the adoption of remaining active in hunting throughout the winter - a highly risk-laden and time-stressed option. Of course, such an option would carry significant adaptational consequences for the relative benefits of adopting alternative high-energy, low-risk resource exploitation strategies such as shellfish exploitation, and this will be discussed later.

At a more generalized level, the loss of predictable concentrations of game in locations and at times when specialized intercept strategies could be successfully employed is of considerable interest when we come to consider the archaeological evidence for anthropogenic clearance activity. As has been discussed previously, the evidence for clearances appears to indicate that if one accepts the role of man in creating and maintaining such clearances then the use of deliberately cleared areas was a widespread feature of Mesolithic strategies after c. 6000 b.c.. The benefits of clearances in terms of promoting increased predictability and higher localized population densities amongst herbivores (see previous chapter) would attain a clear significance in the context of an environment where such predictable concentrations no longer occurred naturally. The degree to which such promoted concentrations would mimic seasonal migration contexts is, of course, dependent upon a number of factors. From our present understanding of clearances it would appear that they were focussed upon the forest margins including the upland elevations. Whilst such cleared locations may have attracted and promoted game concentrations it is not clear if the movement of game could be anticipated and/or controlled in the vicinity of such clearances. In other words, the use of clearances may have served to increase the opportunities for reducing risk in hunting, but it is unlikely that such clearances could have been employed for large-scale anticipatory kills in order to provide stores of food for over-wintering. The implications are that Later Mesolithic hunting strategies were primarily encounter strategies connected with generalized procurement. It should, however, be noted that this discussion has deliberately emphasized the contrasting characteristics of specialized intercept and generalized encounter strategies. In point of fact, the use of hunting blinds or stands near environmental locations where game of different species might be expected to appear (i.e. river margins, spring heads, and clearances) clearly represents a form of intercept strategy (see Binford 1978a: 178 and 342) but such strategies differ from specialized intercept hunting in that they are rarely connected with large-scale kills and tend to be generalist (i.e. take what comes) in character.

Archaeologically, the contrasting hunting strategies suggested for the Earlier and Later Mesolithic convey a series of major implications for site formation, settlement, mobility and technology. The following sections will cover these issues in some detail. In terms of Mesolithic economy the available evidence indicates that whilst plant-food exploitation, coastal resource use and riverine fishing may have achieved some importance the evidence for hunting strategies presents us with a view of the importance of hunting which demands primacy in the consideration of the period. Whatever the difficulties with this latter statement it is clear that discussions of Mesolithic subsistence have traditionally placed the greatest emphasis upon hunting activities. As will become clear, the archaeological record of the Mesolithic may be understood, at least in part, in terms of the strategies connected with hunting and its implications for Mesolithic adaptation.

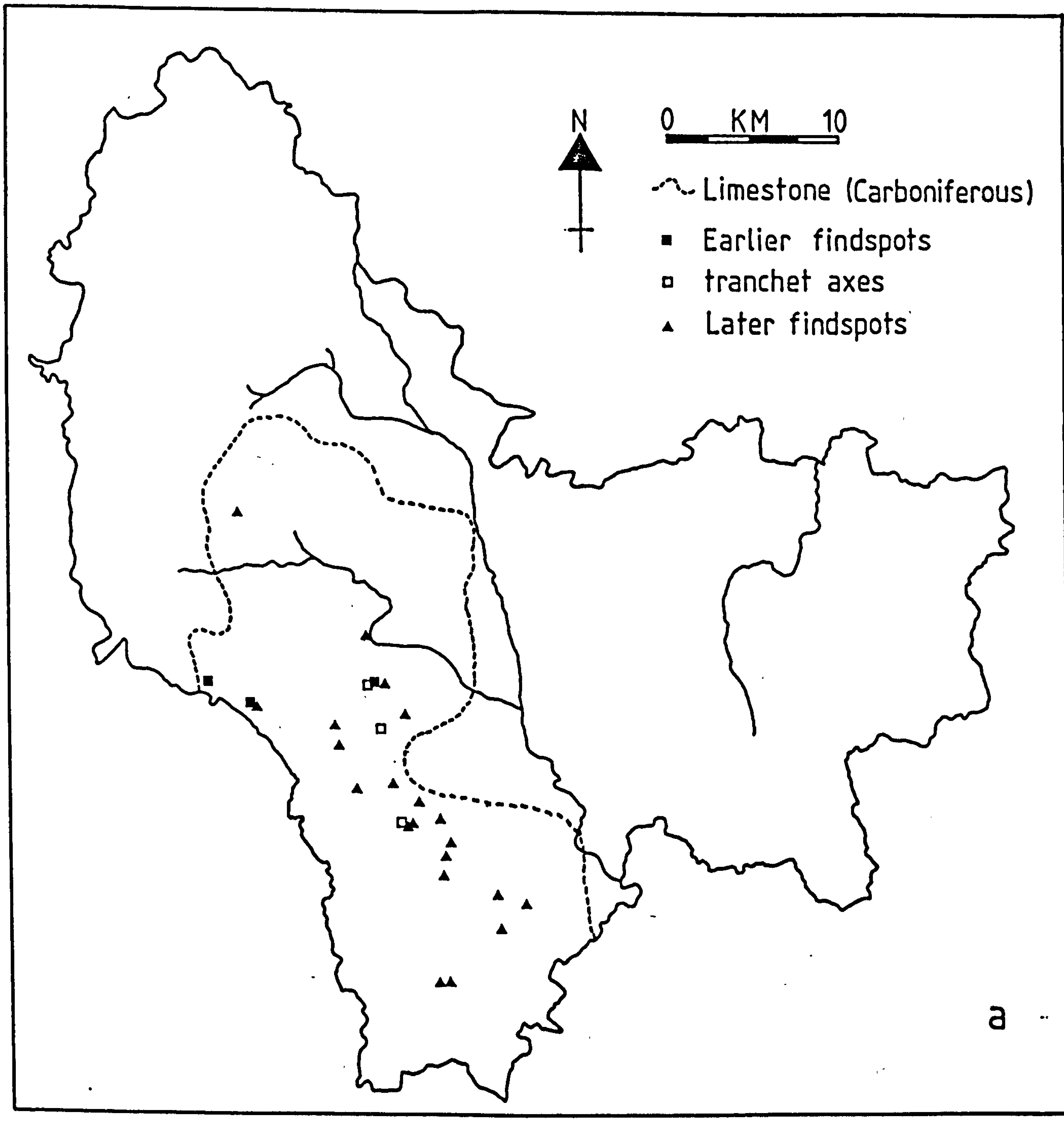
Settlement patterns

Over the years the analysis and discussion of Mesolithic patterns of settlement has attracted a considerable and diverse set of approaches. Ever since the work of Clark (1932, 1936) interest in the relationship between densities of Mesolithic sites and variations in geology and soil type has persisted and flourished (Draper 1968; Jacobi 1978b; Mellars and Reinhardt 1978; Poole 1936). It is beyond the scope of this section to provide a detailed review of these works. It is, however, of considerable interest that one of the more lasting impressions gained through discussions of Mesolithic site distributions concerns the broad differences that have been perceived in the distributional characteristics of Earlier and Later Mesolithic sites. The general characteristics of interest here relate to the numerical representation of sites and the broad locational differences in Earlier and Later Mesolithic occupational debris. Morrison (1980) has summarized these differences thus:

> 'differences between the Earlier and Late Mesolithic phases can be seen in the increased number of sites and greater variety of environments exploited in the later stage.'
>
> (136; my emphasis).

Similarly, and in more detail, Jacobi (1973) has drawn attention to the contrasting nature of Earlier and Later Mesolithic site numbers and locations:

> 'The most striking difference ... between the Earlier and Later Mesolithic is the very large number of demonstrably later sites in many well surveyed areas, such as along the crest and dip-slope of the Cotswolds, on the sands and clays of the Weald/Kent, Surrey and ... Sussex/and on the upper slopes above 1000 ft. on the Pennines and Clevelands, suggesting the ordered exploitation at this time of the whole of inland England and Wales .... This impression is in sharp contrast to that gained for the Earlier period where sites are both fewer in absolute numbers and appear restricted to a limited area....'
>
> (247).


N
0 KM 10
Limestone (Carboniferous)
Earlier findspots
tranchet axes
Later findspots
a

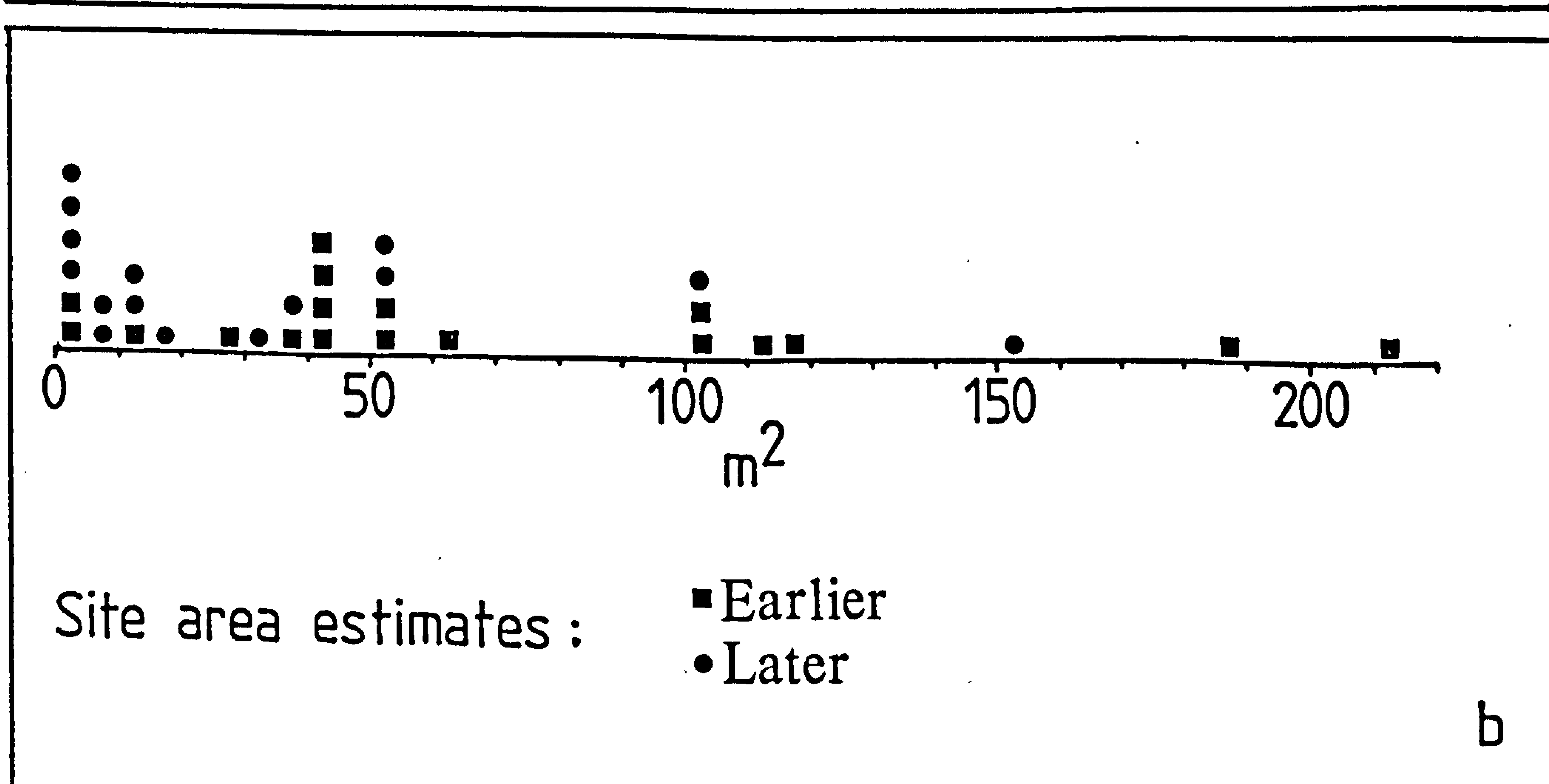

0
50
100
150
200
m2
Site area estimates :
Earlier
Later
b

fig. 21

It has to be said that even if we take the date of 8300 b.c. as the opening of the Earlier Mesolithic the duration of the Later Mesolithic, on present evidence, is very nearly double that of the Earlier period. The increase in site numbers noted for the Later Mesolithic may, therefore, reflect the longer duration of the period. This, of itself, would not explain the apparent expansion of Mesolithic occupational evidence into geological/soil type regions previously 'ignored' in terms of Earlier Mesolithic settlement. Furthermore, the evidence for the 'filling-up' (Jacobi 1973: 251) of the landscape during the Later Mesolithic is accompanied by other general changes in site occupation characteristics. There is a general impression that, in comparison with Earlier sites, the Later Mesolithic sees a reduction in site size with smaller quantities of debris being represented (Care 1982). Clearly, such a change could not be related causally to the duration of the Later Mesolithic.

As confirmation of these general trends in patterns of settlement we can consider the evidence which has been amassed through prolonged and intensive field survey in the Carboniferous limestone region of North Derbyshire (Hart 1981; Manby 1963; Derbyshire County Council Archaeological Scheme 1983 - 1985). It can be seen (fig. 21a)that for the Earlier Mesolithic this upland Carboniferous limestone region has produced evidence which is largely confined to the deep valleys to the west (the previously noted rock-shelter/cave sites of Dowel Cave and Foxhole Cave), the small rock-fissure site at Sheldon (Radley 1968a), and finds of tranchet-axes in isolation from other evidence. By comparison, Later Mesolithic evidence is both more numerous, in terms of numbers of findspots, and more widespread incorporating both valley and plateau locations. Interestingly, it has been suggested (Hart pers. comm.) that many of the finds of Later Mesolithic microliths occur in close association with spring-lines on the arid upland plateau, and the recent discovery of a small, discrete Later Mesolithic assemblage overlooking the Monyash basin - at the centre

APPROXIMATE AREAS FOR MESOLITHIC SITES			
EARLIER	$m.^2$	LATER	$m.^2$
BROXBOURNE	50.0	BADGER SLACKS	> 3.3 (?)
DOWNTON	60.0	BARSALLOCH	> 50.0
DEEPCAR	44.0	BLUBBERHOUSES MOOR	3.3
FLIXTON 1	50.0	BROOMHEAD 5	14.9
IPING COMMON	44.0	DUNFORD BRIDGE A	4.5
MICKLEDEN 3	12.5	DUNFORD BRIDGE B	3.9
MICKLEDEN 4	3.3	LEALT BAY	> 30.0
OAKHANGER 5	100.0	LOW CLONE	54.5
OAKHANGER 7	210.0	LYNE HILL	>150.0 (?)
PIKE LOWE 1	4.2	OAKHANGER 3	100.0
POINTED STONE 2	28.0	OAKHANGER 8	8.8
POINTED STONE 3	39.0	RED RATCHER	16.7
RACKHAM	>112.0	ROCHER MOSS STH.	35.1
STAR CARR	185.0	ROCHER MOSS	8.0 (?)
THATCHAM 1	116.0	WHITE HILL	12.0 (?)
WARCOCK HILL NTH.	>100.0 (?)		
WARCOCK HILL STH.	> 40.0 (?)		
WINDY HILL 3	> 42.0 (?)		

table. 4

of which is a permanent water source - may further indicate the importance of water sources in understanding certain elements of the Later Mesolithic distributional evidence in the limestone uplands (D.C.C. Archaeological Scheme).

The analysis and interpretation of site evidence relating to hunter-gatherer activity in terms of site-size and/or quantities of material represented is notoriously complex and is particularly difficult for the Mesolithic archaeological record (see Mellars 1976a: 377-8). The comparative paucity of structural evidence on Mesolithic sites reduces discussions of site-size to the analysis of lithic distributions and evidence for intra-site lithic concentrations. Clearly, the spatial organization of lithic remains on a given site, in the absence of clear chrono-stratigraphic indicators, may reflect or be influenced by a host of factors. In seeking to compare site-sizes, therefore, it must be acknowledged that such evidence may variously reflect variations in the size of the social unit, the duration of occupation, the frequency of re-occupation, the nature of activities undertaken and the scale of lithic activity - to name but a few. However, purely as a means of illustrating the contrasting impressions of Earlier and Later Mesolithic site-size evidence, without assuming specific causal factors, the available estimates of site-sizes based primarily upon lithic distributional evidence have been compiled (table 4) and graphically illustrated (fig. 21b). Data from sites where the spatial development of lithic concentrations may be constrained by physical limitations of site location (i.e. rock-shelters/caves) or obscured by the presence of alternative debris categories (shell-middens) have been excluded, as have estimates from sites located at lithic sources where quarrying and intensive lithic procurement activity may have influenced frequencies of re-occupation, the nature of activities and the scale of lithic activity. From this limited body of evidence (fig. 21b) it can be seen that, in general terms, Earlier Mesolithic sites tend to be larger than Later Mesolithic sites -

although there is considerable overlap in size ranges. Thus, of 18 Earlier sites only 3 are under 20 m^2, whereas of 15 Later sites 9 are under 20 m^2. This limited body of information would, therefore, appear to confirm that in very general terms Later Mesolithic sites tend to be smaller in area than Earlier sites.

Taken together there would appear to be grounds for suggesting that both in terms of site distribution and sizes of sites the archaeological record reveals changes between the Earlier and Later Mesolithic periods with trends towards the more widespread use of the full range of the landscape and the formation of smaller sites. As previously indicated, the discussion of the causes for such trends, and especially the interpretation of site-size variability, is complicated by the wide range of possible factors involved. In an attempt to analyse and discuss settlement patterns for the Mesolithic of mainland Britain Mellars (1976a) sought to integrate data on site-size with a formal comparison of inter-site industrial variability and a general comparison of locational characteristics for sites. Representing, as it does, the most systematic attempt yet undertaken to analyse patterns of settlement and industrial variability for the period it merits a detailed discussion.

1) <u>Settlement and industrial variability</u>

The approach adopted by Mellars (op. cit.) involved the consideration of Mesolithic site evidence and assemblage variability from a functional, as opposed to a 'cultural', standpoint. No attempt was made during the body of the analysis to distinguish between Earlier, Horsham or Later Mesolithic sites. Consequently, the emphasis was placed upon the discussion of the Mesolithic as a whole.

Employing the available data on site-sizes and structural features Mellars (op. cit.: 379-80) initially constructed a typology of settlements and sought to relate the resulting threefold division to variations in hypothesized social-unit sizes. The category 'type 1' incorporated those sites whose area was no more than approximately 15 m^2 (379), and it was suggested that the evidence indicated that these sites were formed during short-lived occupations by relatively small numbers of people. Mellars (op. cit.: 380) argued that type 1 settlements were unlikely to represent social units of more than five or six individuals, although the precise nature of the social unit (nuclear family or hunting party) was left unspecified.

Type 2 settlements were defined as being between 44 and 210 m^2 in area and were suggested as representing sites occupied by residential groups 'substantially larger' (379) than those associated with type 1 sites. Similarly, type 3 settlements were seen as being spatially extensive, in comparison with type 1 sites, but differing from type 2 settlements in that they show 'a marked tendency to concentrate at several localized points.' (379). These latter 'multiple-focus' (379) sites and the type 2 settlements were suggested as representing occupations by social units at least two or three times larger than in the case of type 1 sites.

Having organized this initial site typology Mellars then proceeded to the analysis of industrial variability. In tabulating lithic inventories from Mesolithic site reports awareness of the lack of consistency in the classification of certain tool-types and by-products led Mellars to restrict his analysis to those categories which, it was felt, offered the greatest measure of overall consistency in classificatory criteria: microliths, scrapers, burins, axes/adzes, and denticulates. To these 'essential tools' (386) were added cores and micro-burins, in being the two least confusable categories of by-product available. As was clearly recognized at the time (385-6) the exclusion of other tool categories, such as awls, truncated flakes, notches and miscellaneous retouched pieces necessarily limited the total available variability in lithic tool assemblage composition (see also Pitts 1979: 33-4), but was a necessary step if published data was to be employed with any degree of confidence. The lack of standardization in classificatory criteria for Mesolithic tools remains a severe handicap in comparative analyses (Jacobi pers. comm.).

Through a visual comparison of the compiled lithic data a series of assemblage types were recognized. Whilst the by-products did enter into the categorization process it is evident that the primary discriminating variables were the 'essential tool inventories', and especially the percentage representations of microliths and scrapers (386). Four assemblage types were identified:

<u>Type A:</u> these were characterized as 'microlith-dominated' assemblages containing 88 - 97% microliths. Accordingly, other tool forms achieve only very low representation.

<u>Type B:</u> these were characterized as 'balanced' assemblages with less than 85% and frequently between 30 and 60% of the essential tool count being comprised of microliths. Other tool forms achieve a higher representation with, for example, scrapers typically contributing between 25 and 50%.

<u>Type B1:</u> these were identified as a sub-group of B and containing more microliths than B, but still exhibiting a range of other tool forms.

<u>Type C:</u> these were characterized as 'scraper-dominated', exhibiting between 82 and 91% scrapers. Apart from low frequencies of microliths and burins no other tool forms were represented.

Having isolated these assemblage types Mellars attempted to correlate the site-size typology with the assemblage typology and found a broad agreement in that the smaller type 1 sites appeared to dominate the type A classification. Similarly, the balanced assemblages (types B and B1) appeared to correspond with the larger type 2 and 3 settlements. In terms of locational characteristics the smaller type 1 microlith-dominated sites were seen to be represented both above 305 metres o.d. and in more low-lying locations. Once again, the larger type 2 and 3 balanced assemblages were noted as being represented in both upland

and lowland locations whilst the type B1 assemblages were identified as exhibiting a correlation with coastal and certain low-lying regions. The scraper-dominated (type C) assemblages were also represented in low-lying and upland locations, and appeared to be relatively small in terms of area (i.e. type 1).

Without entering into a detailed discussion of the various inferences made by Mellars (op. cit.: 380, 383, 389, 392-3) concerning the integration of these site/assemblage types into a coherent model of settlement and seasonality it is clear that the framework employed draws heavily upon the model put forward by Clark (1972) which has already been discussed. However, towards the end of the paper Mellars (op. cit.: 395-7) makes some stimulating observations on the contrasting characteristics of Earlier and Later Mesolithic assemblages. Consideration of these remarks and of the analysis presented by Mellars provides a useful basis for a re-examination of the assemblage characteristics of Mesolithic sites.

2) Earlier and Later Mesolithic assemblage characteristics

Having identified a series of assemblage/site types Mellars considered the contrasting representation of Earlier and Later Mesolithic evidence within the types and made the following observations:

> 'With regard to the earlier stages of the Mesolithic one is struck primarily by the essential uniformity of the assemblages recovered from the different sites. The majority ... fall into the category of 'balanced' (Type B) assemblages.... The late Mesolithic assemblages on the other hand exhibit a much greater degree of variability. The majority of the Type A assemblages can be attributed with some confidence to the second half of the Mesolithic, while Type B assemblages are represented at ... Lyne Hill, Barsalloch, Downton and Farnham. Clear examples of Type C ('scraper-dominated') assemblages appear to be represented by the finds from Blubberhouses Moor and Freshwater West.'
>
> (Mellars 1976a: 395).

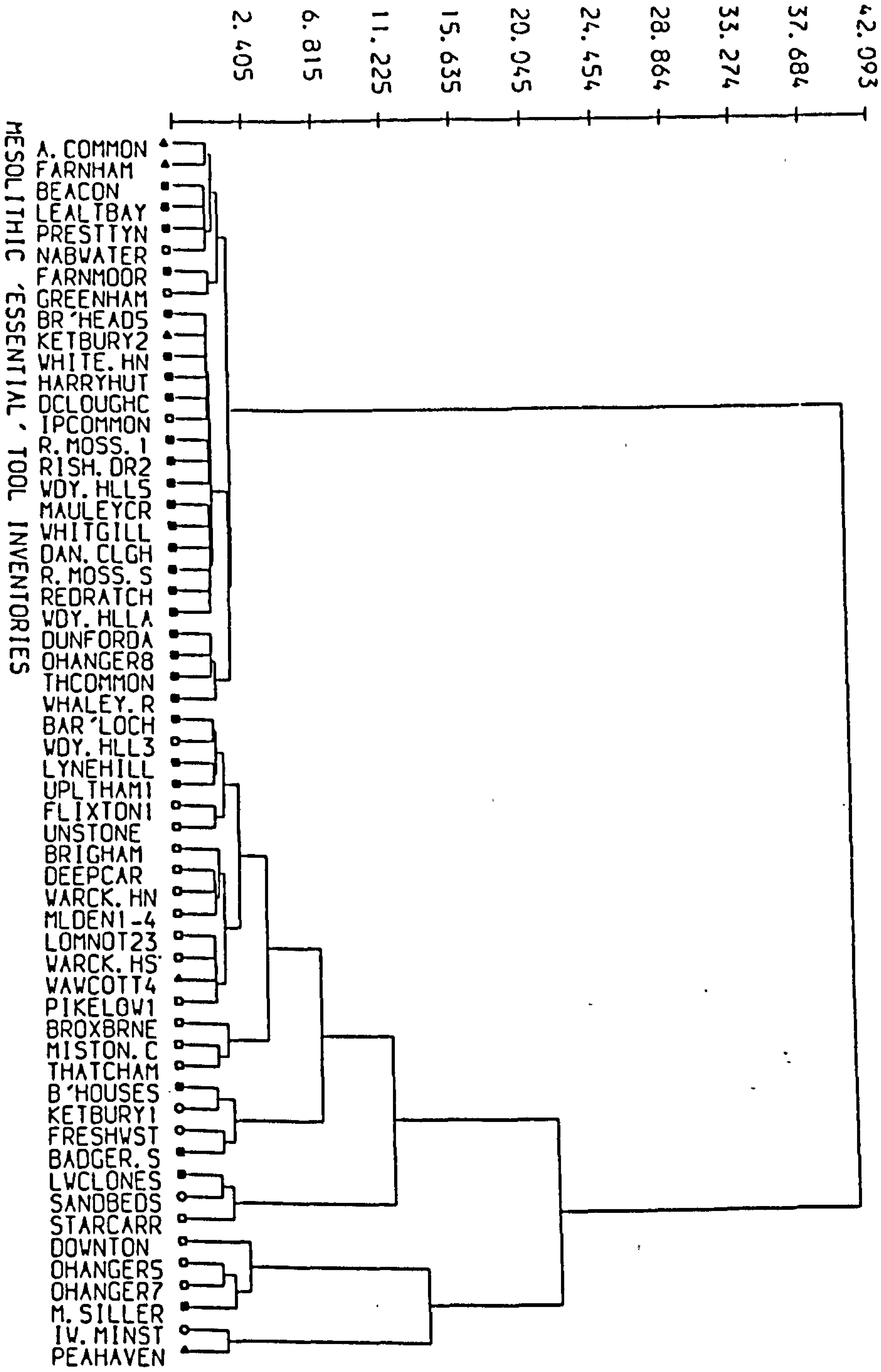
A number of points need to be made at this stage. First, the categories of Earlier and Later Mesolithic employed by Mellars make no distinction between the non-geometric, geometric and Horsham industries as discussed in the previous chapter. Some of the sites described as 'later' belong to the Horsham phase (i.e. Farnham) and, as will become clear, need to be treated independently within inter-assemblage analyses. Second, the site of Freshwater West (Wainwright 1959) has had serious doubts expressed concerning its Mesolithic age (Jacobi pers. comm.; see previous chapter).

Beyond these issues, however, the observations concerning the degree of inter-assemblage variability for Earlier and Later sites may prove highly informative with regard to changes in the overall technological and organizational strategies of Mesolithic populations. In chapter 2 the work of Binford dealing with the effects of curation as a response to scheduling demands was discussed. One of the key predictions concerning the effects of curation was that, other things being equal, higher levels of curation would serve to minimize or reduce inter-assemblage variability. Clearly, the observation that Later Mesolithic assemblages exhibit greater levels of inter-assemblage variability than Earlier Mesolithic assemblages might be taken to indicate a reduction in rates of curation for the 'essential tool forms' during the Later Mesolithic. Such a conclusion would be of considerable importance in the discussion of Mesolithic subsistence and technological strategies and in the comparative discussion of Earlier and Later Mesolithic scheduling behaviour.

Given the potential significance of rates of curation as an index of the scheduling behaviour of Mesolithic groups a re-analysis of the data employed by Mellars has been undertaken. The 'essential tool inventories' employed by Mellars have been expanded through the addition of several sites (table 5) and subjected to multivariate clustering techniques (Wishart 1978) in an initial attempt at replicating the categories identified by Mellars (1976a). Accordingly,

ESSENTIAL TOOL PERCENTAGES FOR MESOLITHIC ASSEMBLAGES					
SITE	MICLITH	SCRAPERS	BURINS	AXE/ADZE	SAWS
ABINGER COMMON	76.4	21.2	1.60	0.80	0.0
BADGER SLACKS 2	21.4	64.3	14.30	0.00	0.0
BARSALLOCH	42.0	47.4	10.50	0.00	0.0
BEACON	82.0	16.9	1.10	0.00	0.0
BLUBBERHOUSES	7.9	90.5	1.60	0.00	0.0
BRIGHAM	48.9	37.6	9.90	0.00	3.5
BROOMHEAD 5	90.0	10.0	0.00	0.00	0.0
BROXBOURNE	43.9	49.2	3.50	3.50	0.0
DAN CLOUGH	96.2	3.8	0.00	0.00	0.0
DEAN CLOUGH C	89.9	8.5	1.70	0.00	0.0
DEEPCAR	59.6	32.5	7.00	0.00	0.9
DOWNTON	47.4	33.1	1.00	3.50	15.0
DUNFORD BRIDGE A	93.2	0.0	6.80	0.00	0.0
FARNWORTH MOOR	88.0	3.0	4.50	0.00	4.5
FARNHAM	75.5	19.8	2.80	1.60	0.1
FLIXTON 1	29.5	62.5	7.20	0.80	0.0
FRESHWATER WEST	0.0	90.1	9.90	0.00	0.0
GREENHAM	78.5	18.1	0.00	0.00	3.4
HARRY HUT	91.3	8.7	0.00	0.00	0.0
IPING COMMON	90.8	8.4	0.80	0.00	0.0
IWERNE MINSTER	39.2	50.0	0.50	7.60	2.9
KETTLEBURY 1	18.2	81.8	0.00	0.00	0.0
KETTLEBURY 2	93.2	6.8	0.00	0.00	0.0
LEALT BAY	84.5	14.3	1.20	0.00	0.0
LOMINOT 2/3	57.2	40.2	2.60	0.00	0.0
LOW CLONE SOUTH	46.1	32.4	21.60	0.00	0.0
LYNE HILL	42.0	52.4	5.60	0.00	0.0
MAULEY CROSS	95.0	3.3	0.80	0.00	0.8
MICKLEDEN 1-4	66.7	28.6	2.40	0.00	2.4
MISTERTON CARR	48.4	39.6	7.70	2.20	2.2
MOTHER SILLER	37.5	37.5	12.50	0.00	12.5
NAB WATER 3	76.9	21.5	1.50	0.00	0.0
OAKHANGER 5	46.1	37.9	0.04	0.04	16.0
OAKHANGER 7	37.4	49.4	0.00	0.05	13.1
OAKHANGER 8	93.3	0.0	6.70	0.00	0.0
PEACEHAVEN	39.4	50.3	0.00	5.70	4.6
PIKE LOWE 1	50.9	47.5	1.60	0.00	0.0
PRESTATYN	81.3	18.7	0.00	0.00	0.0
RED RATCHER	100.0	0.0	0.00	0.00	0.0
RISHWORTH DRAIN 2	96.8	0.0	3.23	0.00	0.0
ROCHER MOSS 1	91.0	6.1	3.00	0.00	0.0
ROCHER MOSS SOUTH	100.0	0.0	0.00	0.00	0.0
SANDBEDS	27.5	46.2	26.30	0.00	0.0
STAR CARR	27.0	35.4	36.30	0.80	0.4
THATCHAM	57.0	25.8	11.40	2.00	3.8
THORPE COMMON	94.0	0.0	6.00	0.00	0.0
UNSTONE 1	32.8	63.9	3.30	0.00	0.0
UPLEATHAM 1	50.9	42.1	7.00	0.00	0.0
WARCOCK HILL NORTH	60.6	32.3	5.10	0.00	2.0
WARCOCK HILL SOUTH	61.9	35.3	2.90	0.00	0.0
WAWCOTT 4	64.3	35.7	0.00	0.00	0.0
WHALEY ROCKSHELTER	78.9	10.5	10.50	0.00	0.0
WHITE GILL	96.7	2.1	0.70	0.00	0.5
WHITE HILL NORTH	92.2	7.8	0.00	0.00	0.0
WINDY HILL A	100.0	0.0	0.00	0.00	0.0
WINDY HILL 3	50.7	37.0	12.30	0.00	0.0
WINDY HILL 5	88.4	7.2	2.90	0.00	1.4

table. 5



□ Earlier Mesolithic. ■ Later Mesolithic.

▲ Horsham Mesolithic. O Mixed/Uncertain.

fig.22

in the initial analysis (fig. 22), no attempt at segregating Earlier, Horsham or Later Mesolithic sites was made. A number of interesting points of comparison between Mellars' classification and the results obtained (fig. 22) using Ward's hierarchical agglomerative clustering technique arise (three other methods - single linkage, average linkage and complete linkage - produced broadly comparable results) and are worth noting.

First, as was suggested by Mellars, the principal division in the data does appear to correspond with the chronological distinction between Later, 'mircolith-dominated' assemblages and Earlier, 'balanced' assemblages. Within this broad separation, however, Earlier assemblages (Nabwater, Greenham and Iping Common) do occur within the 'microlith-dominated' grouping. This aspect of Earlier Mesolithic inter-assemblage patterning was recognized by Mellars (op. cit.: 395). More interestingly, however, Mellars' category B1 sites (Abinger Common, Farnham, Beacon, Lealt Bay, Prestatyn) are clearly represented as a sub-group of the 'microlith-dominated' cluster, and not as a sub-group of the 'balanced assemblage' cluster. This non-conformity demonstrates the difficulties of classifying multivariate data purely through intuitive, visual comparisons.

Similarly, whilst the 'scraper-dominated' (Type C) assemblages (Blubberhouses, Kettlebury 1, Freshwater West) do cluster together there are several more pronounced divisions within the sites classified by Mellars as 'balanced' within which the 'scraper-dominated' assemblages are grouped. If one wished to maintain the 'scraper-dominated' assemblages as an assemblage type the results obtained would suggest that an additional four categories, at least, should also be considered. Most notable of these are the clusters including:

a) Low Clone South, Sandbeds, Star Carr

b) Downton, Oakhanger V, Oakhanger VII, Mother Siller's channel

c) Iwerne Minster, Peacehaven

Cluster 'a' has mean percentage values for microliths, scrapers, burins, axes/adzes and saws of 33.5, 38.0, 28.0, 0.3, and 0.1 respectively. Cluster 'b' has values of 42.0, 39.5, 3.4, 0.9, and 14.2 respectively, whilst cluster 'c' has values of 39.3, 50.1, 0.2, 6.7, and 3.7 respectively. From these figures it is apparent that the single most distinctive feature of cluster 'a' is the relatively high frequency of burins, whilst cluster 'b' contains sites with high frequencies of saws and cluster 'c' contains a relatively high frequency for axes/adzes. The characterization of site assemblages by reference to any single tool form's representation, however, does not reflect the multivariate basis for the classification process and underlines, once again, the dangers of visual, intuitive approaches as adopted by Mellars. It is not the purpose of this analysis to seek to erect alternative typological categories, but rather to illustrate some of the more subtle dimensions of inter-assemblage variability not uncovered through Mellars' approach.

The clear chronological component in the major division of assemblages emphasizes the need for the initial classification of Mesolithic tool inventories to be undertaken separately within the Earlier and Later data. Accordingly, those sites belonging to Horsham-type industries, and those whose chronological associations are uncertain have been excluded from further analysis. Sites with assemblages clearly belonging to either Earlier or Later Mesolithic industrial contexts have been tabulated separately and subjected to further analysis. It is important to stress that, once again, the objective of this work was not to identify or construct an assemblage typology, but rather to provide a broad comparative base for examining the observations made by Mellars concerning the relative variability of Earlier and Later Mesolithic assemblages.

a) Methodology and rationale

For both the Earlier and Later Mesolithic 'essential tool inventories' four separate agglomerative hierarchical clustering techniques were applied. Such techniques proceed from a matrix of similarities or differences which depict the relationships of individual cases (clusters) to be classified. This matrix is used as the basis for identifying 'similar' cases which may then be joined to form the next cluster. Accordingly, the clustering procedure may be regarded as a series of attempts to find the most efficient step, in some predefined sense, at each stage in the procedure (Everitt 1974). At each step the joining of the most similar or least dissimilar clusters results in a reduction by one of the number of clusters.

The use of clustering techniques for classificatory purposes has received considerable attention and criticism from archaeologists (Aldenderfer 1982; Doran and Hodson 1975; Hodson 1969a, 1969b; Hodson et al. 1966) as well as in the broader realm of multivariate numerical taxonomy (Jardine and Sibson 1968, 1971; Lance and Williams 1967; Williams et al. 1971; Sneath 1969). Whilst much of the debate has concerned the mathematical rigour of differing techniques (i.e. Jardine and Sibson 1971; Lance and Williams 1967) some of the most interesting discussions have dealt with the problems of cluster validation (Aldenderfer 1982; Sneath 1969). The acceptance of any given cluster solution as a meaningful or valid basis for a taxonomic framework has been argued to be dependent upon so-called 'external criteria' (Sneath 1969: 257), but Aldenderfer (1982) has argued that such criteria may themselves be subject to disagreement. Consequently, Aldenderfer stresses the need to employ objective criteria in the final acceptance of a given clustering solution.

Whilst the issues of this debate are concerned with the search for taxonomic structure they raise a number of points relevant to the approach adopted here.

First and foremost, the differing techniques of clustering employ fundamentally opposed definitions of distance or similarity which may recognize clusters that differ in their composition and shape. It follows, therefore, that the definition of clusters using any single technique may prove more or less successful depending upon a) the particular strengths or weaknesses of that technique, and b) the distance/similarity characteristics of the data-set to be employed. The second point follows on in that, as stressed by Aldenderfer (op. cit.: 63), it is preferable to employ a variety of clustering methods which 'reflect very different perspectives on the nature of clusters and the way in which clusters are formed.'.

Accordingly, the four techniques employed were selected on the basis that a) they were ultimately comparable in as much that they are all agglomerative hierarchical techniques, and b) they employ very different definitions of cluster nature and shape. The four techniques used are:

1) Single-linkage, or nearest neighbour analysis,

2) Complete-linkage, or farthest neighbour analysis,

3) Average-linkage,

4) Ward's minimization of error-sum of squares (E.S.S.).

Single-linkage joins clusters on the basis of those individual cases that are closest to one another, regardless of the distance to other cases contained in the clusters to be joined. Complete-linkage joins clusters on the basis of the minimal distance resulting from comparing the most distant cases contained within any two clusters. Average-linkage joins clusters on the basis of minimizing the average distance, calculated on the cases contained within clusters, between clusters. Ward's method joins clusters

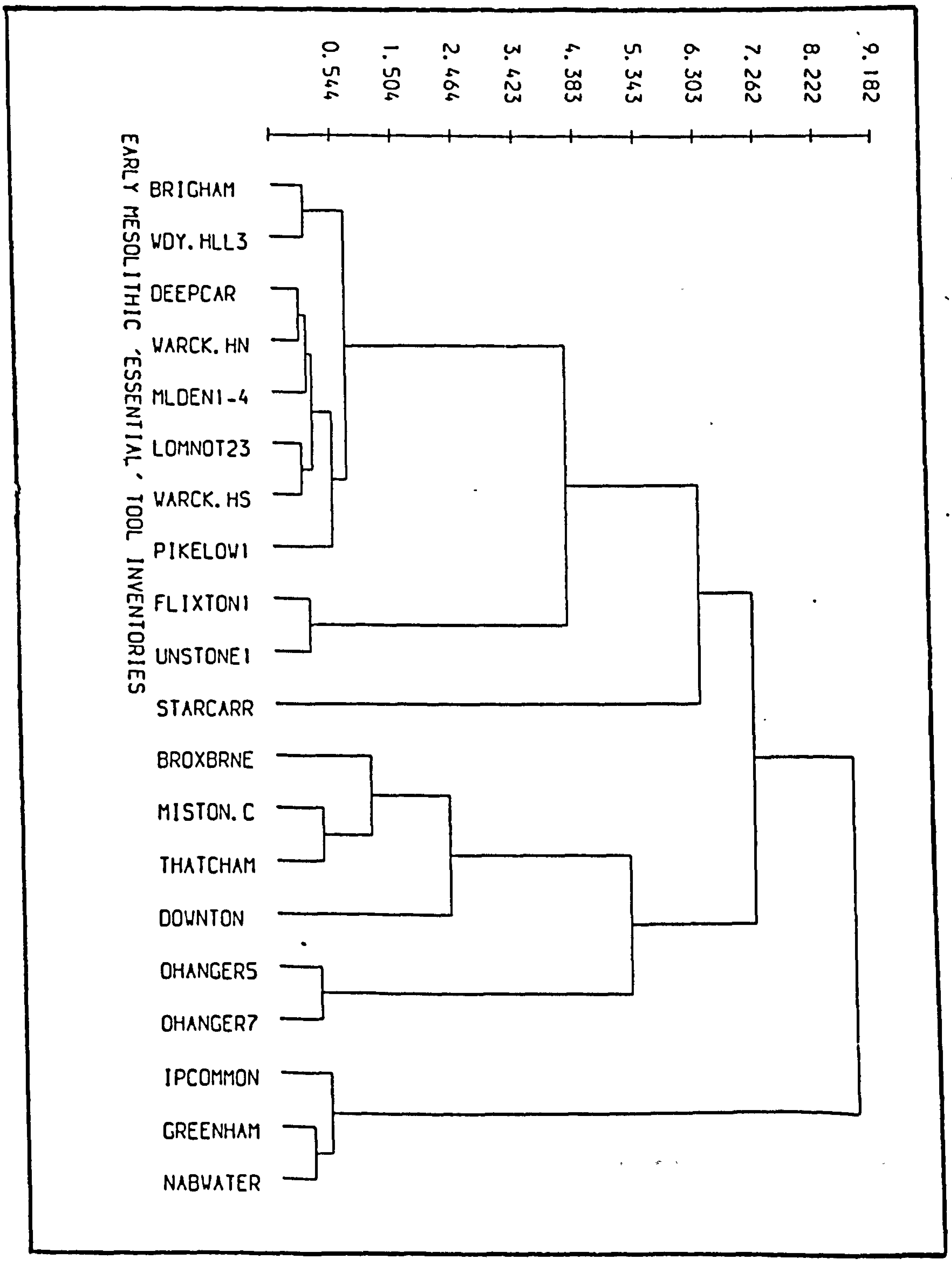

0.544
1.504
2.464
3.423
4.383
5.343
6.303
7.262
8.222
9.182
EARLY MESOLITHIC 'ESSENTIAL' TOOL INVENTORIES
BRIGHAM
WDY.HLL3
DEEPCAR
WARCK.HN
MLDEN1-4
LOMNOT23
WARCK.HS
PIKELOW1
FLIXTON1
UNSTONE1
STARCARR
BROXBRNE
MISTON.C
THATCHAM
DOWNTON
OHANGER5
OHANGER7
IPCOMMON
GREENHAM
NABWATER

fig.23

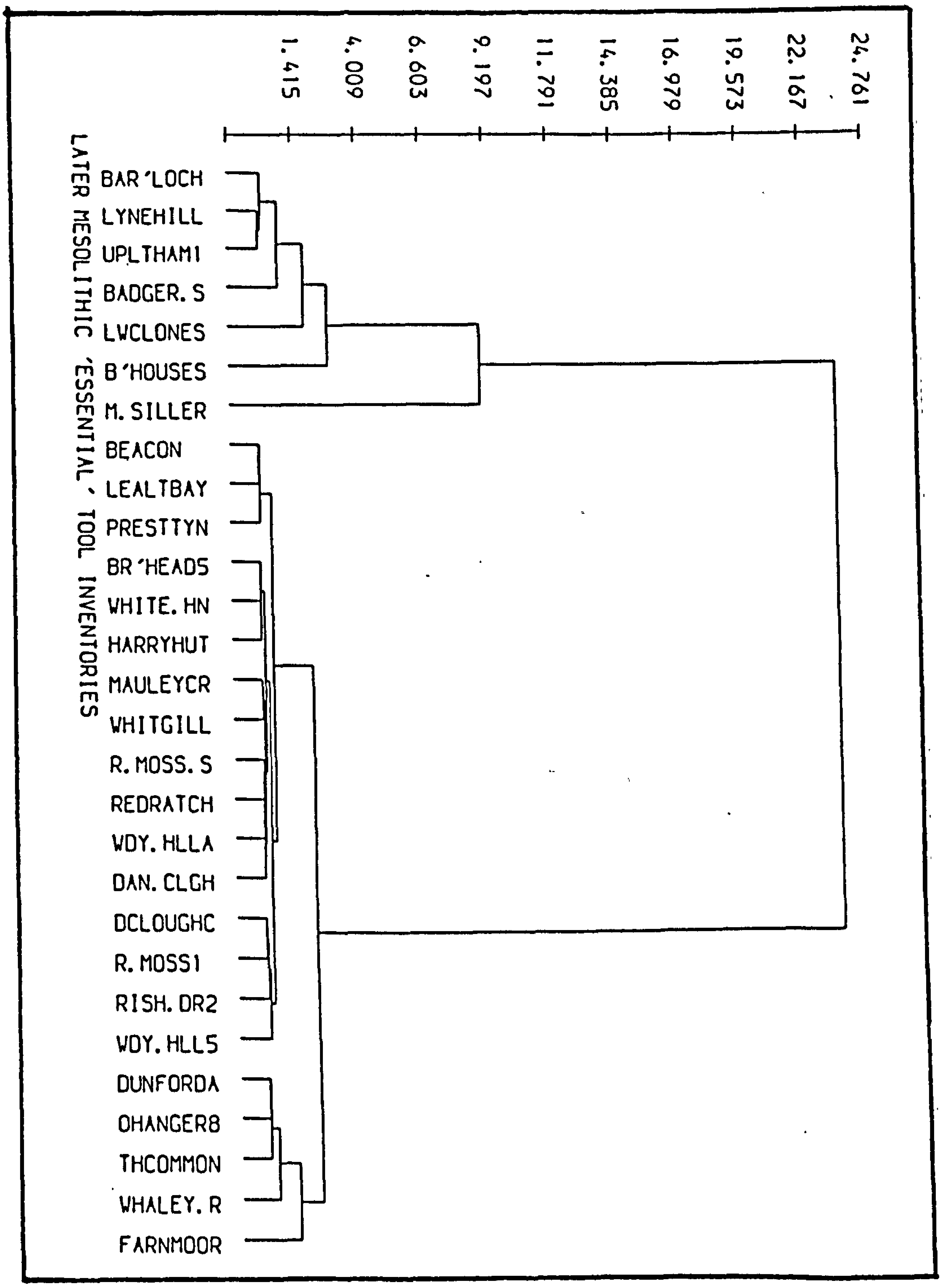

LATER MESOLITHIC 'ESSENTIAL' TOOL INVENTORIES
1.415
4.009
6.603
9.197
11.791
14.385
16.979
19.573
22.167
24.761
BAR'LOCH
LYNEHILL
UPLTHAM1
BADGER. S
LVCLONES
B'HOUSES
M. SILLER
BEACON
LEALTBAY
PRESTTYN
BR'HEADS
WHITE. HN
HARRYHUT
MAULEYCR
WHITGILL
R. MOSS. S
REDRATCH
WDY. HLLA
DAN. CLGH
DCLOUGHC
R. MOSS1
RISH. DR2
WDY. HLL5
DUNFORDA
OHANGER8
THCOMMON
WHALEY. R
FARNMOOR

fig. 24

on the basis of minimizing the increase in the error-sum of squared distances resulting from cluster fusion.

The resulting cluster outputs were then subject to comparison through the calculation of the percentage increase in the coefficient of distance with each cluster cycle. As each technique seeks, in various ways, to minimize the resulting increase in the distance coefficient those cluster cycles which result in the joining of highly dissimilar clusters should be reflected in a large relative increase in the coefficient. In other words, where the data-set does incorporate significantly different assemblage cluster types the fusion of these clusters with other clusters should produce marked increases in the percentage increase of the coefficient of distance for that cycle. The dendogram outputs for the analyses have been separated, with the Ward's method outputs for Earlier (fig. 23) and Later (fig. 24) analyses being included in the text, and the outputs from the other three techniques being placed in appendix 2.

b) <u>Results</u>

From the analyses of percentage increases in the coefficient of distance (table 6) it can be seen (fig. 25) that, for the final eight cycles, there are both pronounced consistencies for the four techniques within the two periods, and marked differences between the Earlier and Later results. If it is accepted that we might expect to identify behaviourally significant assemblage types within the final eight cycles then the observed differences between the Earlier and Later results may prove highly informative with regards to the observations by Mellars that Later Mesolithic assemblages exhibit greater levels of inter-assemblage variability.

For the Earlier Mesolithic analysis it can be seen (fig. 25) that the highest percentage increases occur in the average-linkage analysis for the cycle to form seven clusters (138.83%) and in the Ward's method analysis for the cycle to form six clusters (113.33%). Apart from these two instances none of the other cycles have percentage

CLUSTER LEVEL	SINGLE dc.	%	COMPLETE dc.	%	AVERAGE dc.	%	WARD'S dc.	%
8	0.303	(8.91)	0.927	(45.31)	0.376	(138.83)	0.742	(46.63)
7	0.330	(36.36)	1.347	(37.19)	0.898	(31.07)	1.088	(113.33)
6	0.450	(21.33)	1.848	(5.47)	1.177	(47.24)	2.321	(81.39)
5	0.546	(33.88)	1.949	(54.54)	1.733	(11.94)	4.210	(22.61)
4	0.731	(68.95)	3.012	(54.58)	1.940	(14.95)	5.162	(22.07)
3	1.235	(33.44)	4.656	(33.08)	2.230	(22.33)	6.301	(13.70)
2	1.648	(36.95)	6.196	(24.61)	2.728	(67.82)	7.164	(22.08)
1	2.257		7.721		4.578		8.746	

EARLIER MESOLITHIC CLUSTER ANALYSES

CLUSTER LEVEL	SINGLE dc.	%	COMPLETE dc.	%	AVERAGE dc.	%	WARD'S dc.	%
8	0.119	(64.71)	0.273	(194.87)	0.215	(80.47)	0.477	(79.45)
7	0.196	(68.37)	0.805	(12.67)	0.388	(57.73)	0.856	(35.40)
6	0.330	(2.42)	0.907	(5.40)	0.612	(22.18)	1.159	(65.54)
5	0.338	(102.66)	0.956	(68.62)	0.752	(76.86)	1.907	(9.49)
4	0.685	(35.18)	1.612	(176.43)	1.330	(51.35)	2.088	(36.69)
3	0.926	(6.91)	4.456	(24.08)	2.013	(41.38)	2.854	(215.52)
2	0.990	(275.15)	5.529	(41.73)	2.846	(132.64)	9.005	(161.89)
1	3.714		7.836		6.621		23.583	

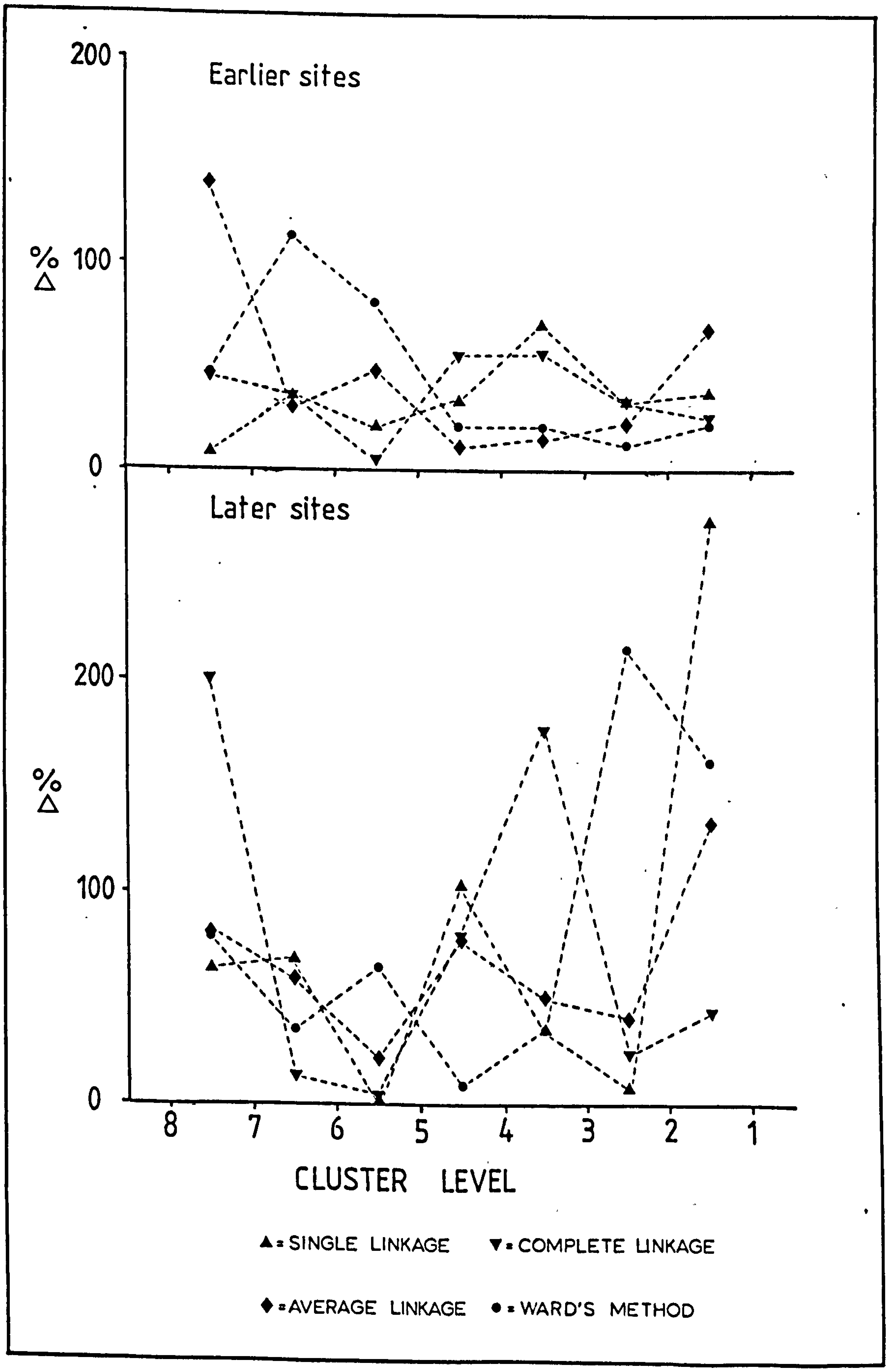
LATER MESOLITHIC CLUSTER ANALYSES

table.6

EARLIER MESOLITHIC	MIC'LITH	SCRAPER	BURIN	AXE/ADZE	SAWS
CLUSTER 1	55.70	37.50	5.90	0.00	0.90
CLUSTER 2	31.50	63.20	5.20	0.40	0.00
CLUSTER 3	41.70	43.60	0.02	0.04	14.50
CLUSTER 4	49.70	38.20	7.50	2.50	2.00
CLUSTER 5	47.40	33.10	1.00	3.50	15.00
CLUSTER 6	82.10	16.00	0.80	0.00	1.10
CLUSTER 7	27.00	35.40	36.30	0.80	0.40
LATER MESOLITHIC					
CLUSTER 1	35.00	54.80	10.10	0.00	0.00
CLUSTER 2	91.50	5.80	2.30	0.00	0.30
CLUSTER 3	37.50	37.50	12.50	0.00	12.50

MEAN ESSENTIAL TOOL PERCENTAGES FOR ASSEMBLAGE CLUSTERS

table.7



200
Earlier sites
%
Δ
100
0
Later sites
200
%
Δ
100
0
8
7
6
5
4
3
2
1
CLUSTER LEVEL
▲= SINGLE LINKAGE
▼= COMPLETE LINKAGE
♦ = AVERAGE LINKAGE
● = WARD'S METHOD

fig. 25

increases above 90%. By comparison, the Later Mesolithic analysis shows percentage increases above 100% for all four methods and increases of over 190% in three. Furthermore, there is a very clear impression of pronounced increases for all methods during the final three cycles (> 130%). Both in terms of the scale of percentage increases and in terms of consistency in high percentage increases between the four methods there would appear to be confirmation that Later Mesolithic assemblage clusters exhibit higher levels of 'cost' in terms of the distance coefficient as a result of their fusion than do Earlier Mesolithic assemblages. Consequently, we may conclude that on the basis of this analysis Later Mesolithic assemblages do contain greater levels of inter-assemblage variability and a tendency to form distinct assemblage 'types'.

Before proceeding to consider the implications in terms of curation rates it is worth making some observations upon the character and consistency of site-assemblage associations within and between the clustering methods. As far as the Earlier assemblages go there are certain consistent patterns of association which cross-cut the four clustering methods although it must be remembered that individually the degree of separation between clusters is not statistically clear-cut. We can tentatively identify seven clusters, listed below, whose mean essential-tool frequencies are given in table 7.

1) Brigham, Windy Hill 3, Deepcar, Warcock Hill North, Lominot 2/3, Warcock Hill South, Pike Lowe 1 (Mickleden 1-4?).
2) Flixton 1, Unstone 1.
3) Oakhanger V, Oakhanger VII.
4) Misterton Carr, Thatcham and, less clearly, Broxbourne.
5) Downton.
6) Greenham, Nabwater and, less clearly, Iping Common (Mickleden 1-4?)
7) Star Carr.

One immediate impression from these tentative cluster 'types' is the impressive internal consistency and homogeneity of the Pennine assemblages in cluster 1. Just such a situation was partially anticipated by Mellars (1976a: 395). Another interesting point concerns the variation within lowland sites (Oakhanger V/VII, Misterton Carr/Thatcham, Downton, Star Carr) which appears to reflect the varying representations of tools that are generally not well represented in the data-set as a whole (burins, axe/adzes, saws). Thus, cluster 3 contains an unusually high frequency of saws, whilst clusters 5 and 7 reflect higher than expected frequencies of saws and axe/adzes in the former and of burins in the latter. In general it can be seen (table 7) that lowland assemblages tend to contain, in varying proportions, a more diverse and balanced set of tool forms than do the upland (cluster 1) sites.This pattern is not, however, absolute in that microlith-dominated sites (cluster 6) occur in both upland (Nabwater) and lowland (Greenham, Iping Common) locations. Similarly, the site of Brigham (cluster 1) does not conform to the pattern of more balanced lowland assemblages.

Turning to the Later assemblages a preliminary examination of the cluster analyses results suggests a minimum of three highly distinct cluster 'types' within which certain secondary groupings may be identified.

1) Barsalloch, Lynehill, Upleatham 1 - and possibly Low Clone South and Blubberhouses Moor.

2) Beacon, Lealt Bay, Prestatyn, Broomhead 5, White Hill North, Harry Hut, Mauley Cross, White Gill, Rocher Moss South, Red Ratcher, Windy Hill A, Dan Clough, Dean Clough C, Rocher Moss 1, Rishworth Drain 2, Windy Hill 5, and possibly Dunford A, Oakhanger 8, Thorpe Common, Whaley Rockshelter, as well as, possibly, Farndale Moor.

3) Mother Siller's Channel.

It is apparent from the mean essential-tool frequencies for the three clusters (table 7) that the primary discriminating variable in forming these distinct cluster 'types' is the representation of microliths. Whereas clusters 1 and 3 exhibit microlith frequencies of approximately 35% the figure for cluster 2 is 91.5%. The factor separating clusters 1 and 3 is the high frequency of saws in cluster 3, and the resulting lower frequency of scrapers in comparison to cluster 1. The other important feature of the Later Mesolithic data-set is the total absence of axe/adzes. It is well understood that the Later Mesolithic in northern England and Scotland witnesses a complete absence of such core axes, whereas in southern England such tools persist in Horsham industries and in certain Later Mesolithic assemblages (i.e. Culver Well). The underrepresentation of Later sites from southern England in the data-set has meant that core axes are not represented in this, or for that matter, in Mellars' analysis. Consequently, the discussion of Earlier and Later industrial variability is, for comparative purposes, not strictly a comparison of like with like.

The implications of these results must, in the light of the absence of axe/adzes from the Later data, be treated with considerable caution when considering the evidence for increased inter-assemblage variability during the Later period. As noted previously, one of the conditions underlying Binford's expectations, with respect to the effect of curation, was that other things should be equal, in the comparison of diachronic industrial variability. Even if we acknowledge that the overall low level of axe/adze representation may not have significantly influenced the results the awareness of changes in Mesolithic tool-kits presents us with further, potentially significant, problems. For the statistical comparison of Earlier and Later Mesolithic tool inventories to inform us in an unambiguous fashion about changes in the degree of distinct assemblage-type formation it must be assumed that the categories of tool included in such comparisons must be directly comparable. Although it may be safe to assume that scrapers, burins and saws continue to perform similar ranges of tasks between the two periods there are clear grounds for suspecting that the technological/functional role of microliths may have undergone significant changes.

3) Curational versus situational Mesolithic technology

Within the specific tool form classes considered above certain observations need to be made concerning their roles as curated or expediently/situationally produced (see chapter 2) artefacts.

a) Scrapers: Conventionally, scrapers have been regarded as tools employed in the working of animal skins or as woodworking tools. Beyond these simple assumptions concerning function little has been said concerning their relative roles as curated or expedient tool forms. Reasons for this absence of concern may relate to the problems of associating discarded scrapers with debris that clearly relates to either their manufacture or maintenance. Beyond the powerful but highly time-consuming technique of re-fitting (see Cahen et al. 1979) we cannot securely relate by-products of scraper manufacture/maintenance with deposited tools. However, two lines of reasoning may inform us as to the role of scrapers in these technologically related strategies. First, the re-fitting and micro-wear analyses undertaken at Meer, Belgium (Cahen et al. 1979), with a core and blade industry served to illustrate that the eight scrapers recovered were all manufactured, used and deposited on the same site (666). Second, whilst scrapers are almost a ubiquitous feature of the Mesolithic assemblages considered above it is striking that certain sites have produced unusually high numbers of such tools (Blubberhouses Moor n = 57, Flixton 1 n = 165, Star Carr n = 326) and achieve high percentage contributions in the essential tool inventories of certain sites (Blubberhouses Moor 90.5%, Kettlebury 1 81.8%). If it is accepted that, functionally, scrapers were associated with craft activities then the marked representation of such tools in certain sites taken together with the evidence for manufacture, use and discard of scrapers at Meer might suggest a strongly situational, non-curated role for such tools.

However, it is equally possible, if not probable, that some scrapers were hafted for use (Keeley 1982: 805) and consequently were subject to prolonged and anticipatory maintenance and transportation. At present, therefore, we may conclude that scrapers functioned within both situational and curational designs. There are, as yet, no criteria that would inform us about shifts in the balance of these strategies of scraper use between the Earlier and Later Mesolithic.

b) Burins: Our understanding of the function of burins rests largely upon the evidence from Star Carr (Clark 1954) for their use as grooving tools in association with the production of antler splinters. The re-fitting of burin spalls onto burins at Star Carr points to their situational role as does the high frequency achieved by burins at certain sites (Low Clone South 21.6%, Sandbeds 26.3%, Star Carr 36.3%). The fact that such evidence comes from Earlier and Later Mesolithic sites, combined with a re-fit of a primary burin spall at the Later site of Badger Slacks 2 (Buckley 1924: 3), might further indicate the continuity of burins as expediently manufactured tools throughout the Mesolithic.

c) Saws: Of the tool-categories included by Mellars in the essential tool inventory it is the recognition of denticulated flakes or blades which probably represents the least systematically defined or recognized category. Quite apart from the wide range of flake/blade shapes which were modified into denticulated pieces many uncertainties arise in separating denticulates from flakes with multiple notches along one edge. These doubts aside, the high frequencies of saws found on just a few sites (Downton 15%, Oakhanger V 16%, Oakhanger VII 13.1%) might suggest an expedient role. Certainly, it is difficult to associate such tools with anything other than craft activities, although their precise function(s) remains uncertain. Their occurrence on Earlier and Later (Mother Siller's Channel 12.5%) sites in high frequencies might suggest their continuity as an expedient tool form in both periods, although we cannot, as yet, associate particular categories of by-product with their production.

d) Axe/adzes: Of the tool forms considered thus far it is, perhaps the axe category which stands out as the clearest example of a curated item. Not only do we have a reasonable understanding of at least one of the functions of axes (tree-felling, as demonstrable from Star Carr), we can also recognize one distinctive by-product from the resharpening of the working edge (transversely struck axe-sharpening flakes). It appears evident that these tools were hafted and subject to repeated resharpening, in which case they were almost certainly transported. At Pike Lowe 1 (Radley and Marshall 1965) a single axe-sharpening flake was recovered although no axe was found, indicating the probable removal of the tool for use elsewhere. Consequently, we might expect that axes were subject to transportation, resharpening, usage and further transportation over extended periods. In other words, their contexts of manufacture need not coincide with their contexts of eventual discard. It is worth considering, however, that the procurement of wood - an activity undoubtedly involving axe-usage - need not have been an activity undertaken at the same level of intensity throughout the year. We might, for example, expect firewood collection to be a particularly important activity during the colder months. If so, then it might be expected that sites occupied during colder periods may produce more evidence for the resharpening of axes than sites occupied during warmer months. In the context of a highly logistical system axes may have become elements of site furniture (sensu Binford 1976) on sites anticipated as residences for cold months of the year, and subject to lower levels of transportation than items of personal gear.

e) Microliths: As discussed earlier in this chapter, the functions of microliths have been traditionally related to hunting activities. As Clarke (1976) has stressed, such an assumed role cannot be justified for all technologies that include microlith manufacture. There are, however, very strong grounds for believing that most, if not all, of the microlithic equipment in the context of the British mainland Mesolithic were components in the construction of projectile technology. Two related lines of archaeological evidence serve to confirm the traditional interpretation for such tools; finds of microliths in direct association with hunted animals, and finds of multiple microliths, isolated from other categories of lithic debris, where the original layout of the components in a single composite tool may be recognized. Apart from confirming the projectile interpretation for microliths the combined evidence from these two types of find provides us with a powerful means of examining changes in microlithic projectile technology within the Mesolithic. In view of the fact that variations in the microlithic component of Mesolithic assemblages accounted for 41.35% of the total variation for Earlier and 48.73% of the total variation for Later assemblages within the cluster analyses discussed previously it is clear that evidence for significant changes in the character of microlithic technology between the periods would reflect significantly upon such comparative analyses.

Given the analytical significance of microliths to the study of Mesolithic industries it is appropriate to discuss these lines of evidence in some detail. Accordingly, the following sections will focus upon these differing issues in turn.

4) Microliths and hunting

Within the broader European context discoveries of animal bones exhibiting injuries inflicted by Mesolithic projectiles have, occasionally, been recovered with portions of microliths still embedded in the bone (Noe-Nygaard 1974;

Rozoy 1978: 957-8). On the British mainland such occurrences are rare. At Lydstep Haven (Jacobi 1980b: 175) the remarkable discovery of a wild pig with a pair of narrow 'rod-type' microliths apparently lodged within the pig's neck vertebrae appears to have survived for our examination as a result of an almost unbelievable sequence of events in the life and death of this unfortunate animal. It would appear that having been injured by a hunter's arrow this animal avoided capture only to be crushed by a falling tree! In a similar fashion, the discovery of an aurochs skeleton at Ham Marsh near Newbury (Jacobi 1980b: 175) with what is assumed to be a microlith lodged in the frontal sinus appears to represent another instance where an animal, having been injured by an arrow, escaped its hunters. In both cases we have evidence for the use of microliths as components in projectiles associated with hunting.

Beyond these rare associations of microliths directly with the hunted prey evidence for the use of microliths as components of projectile technology can be found from a number of cases where the original shape of microlithic equipment has been preserved. At Risby Warren V some eight small triangles were found 1 to 1 1/4 inches apart at right angles to a discoloured mark in the sand (Walshaw notebooks; Jacobi pers. comm.). Similarly, the discovery of some 35 microliths, principally small rhomboids, organized in a straight line slightly over 6 feet long (Buckley notebooks vol. 1: 15; Petch 1924: 29) at intervals of 1 1/2 to 2 inches at Readycon Dene, near White Hill, appears to represent the remains of a single, very large and complex projectile. Once again, at Urra Moor, North Yorkshire, some 25 rhomboid microliths were found at approximately 2 to 3 inch intervals in a straight line between 50 and 75 inches long (Jacobi pers. comm.). Whilst the discoveries from Readycon Dene and Urra Moor appear to relate to individual projectiles their size would appear to rule out their originating from arrow-shafts.

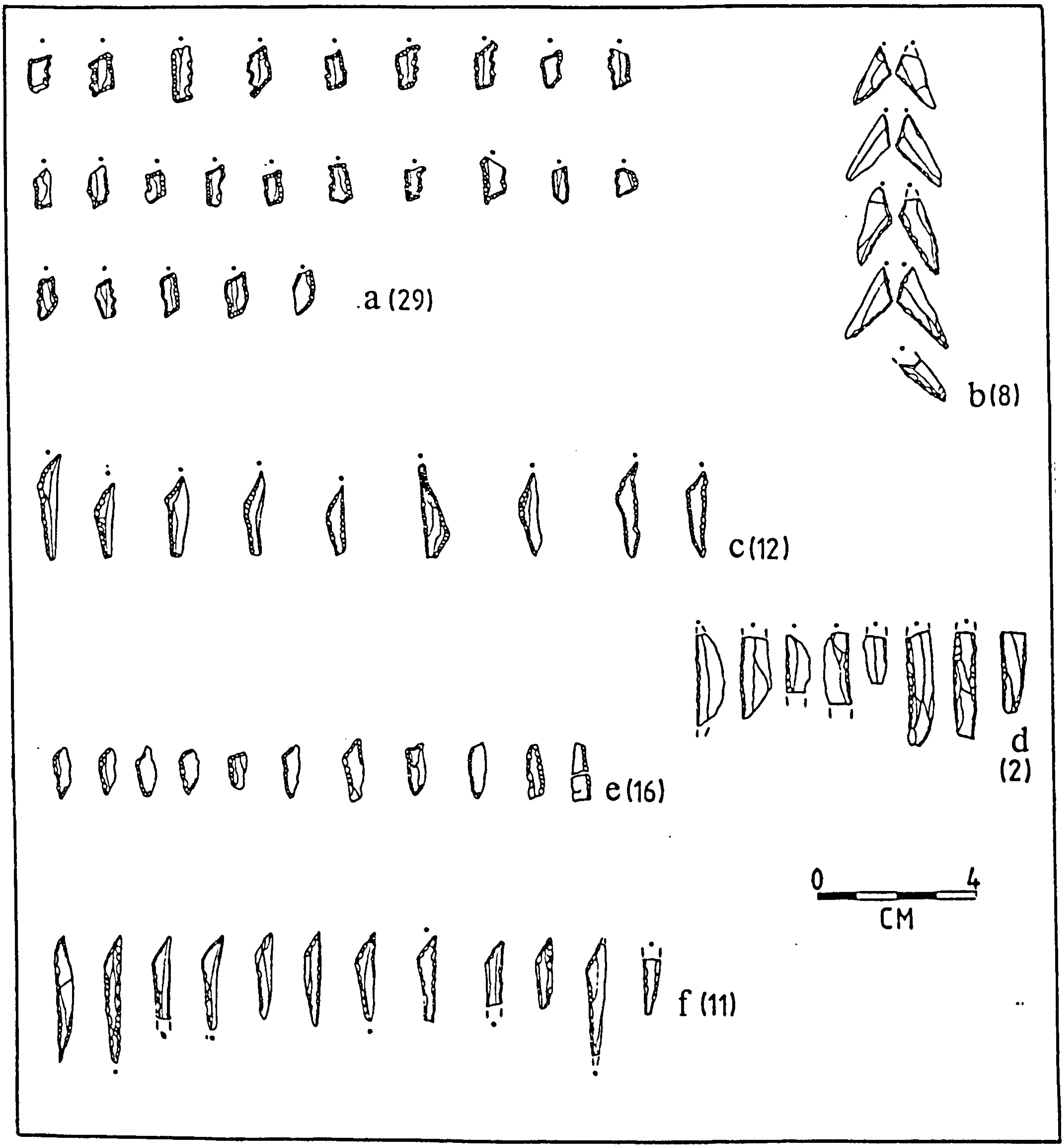

a (29)
b (8)
c (12)
d (2)
e (16)
f (11)
0
4
CM

fig. 26

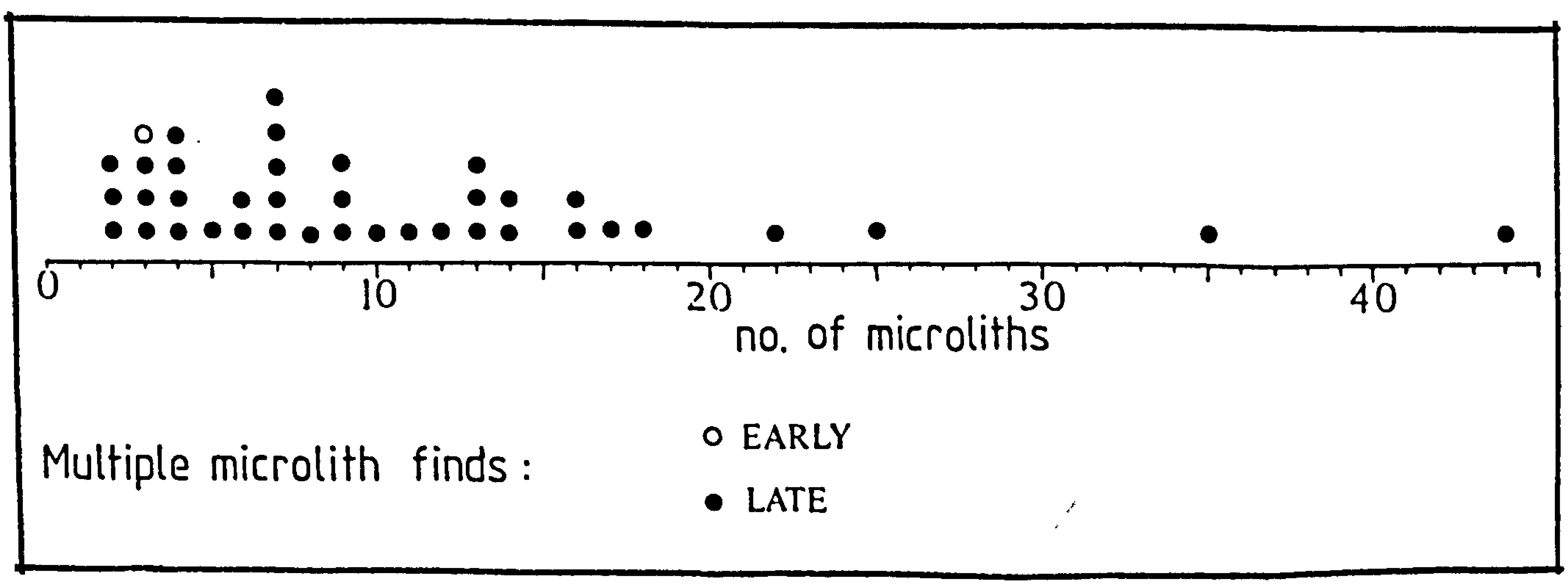

0
10
20
30
40
no. of microliths
Multiple microlith finds :
EARLY
LATE

fig. 27

MULTIPLE MICROLITH FINDS	LATER					EARLIER
	RODS	TRIANGLES	RHOMBOIDS	OTHER	BROKEN/ UNCERTAIN	EARLIER FORMS
1) URRA MOOR	22	-	-	-	-	-
2) COW RIDGE	7	-	-	-	-	-
3) ARNSGILL RIDGE	10+	-	-	-	-	-
4) SIL HOWE BOG	6	-	-	-	-	-
5) HOLIDAY HILL	14	-	-	-	-	-
6) COCKAYNE	13+	-	-	-	-	-
7) TAG HEYS	17	-	-	1	-	-
8) URRA MOOR	-	8	-	-	1	-
9) URRA MOOR	-	5	-	1	1	-
10) URRA MOOR	-	8	-	-	5	-
11) EAST BILSDALE MOOR	-	9	-	-	3	-
12) MONEY HOWE	-	9	-	-	-	-
13) WHITE GILL	-	6	-	-	1	-
14) WHITE HASSOCKS	-	43	-	-	1	-
15) BLUBBERHOUSES MOOR	-	6	-	-	-	-
16) BLUBBERHOUSES MOOR	-	9	-	-	2	-
17) WHITE HILL SUMMIT G	-	3	-	-	1	-
18) N. W. of WINDY HILL	-	4	-	-	-	-
19) TOP of WINDY HILL	-	2	-	-	1	-
20) MANSHEAD HILL	-	6	-	-	1	-
21) S. SIDE CUPWITH HILL	-	4	-	-	-	-
22) RISBY WARREN 5	-	8	-	-	-	-
23) READYCON DENE	-	1	21	-	13	-
24) NEAR WINDY HILL	-	-	7	-	6	-
25) DRY CLOUGH	-	-	14	-	-	-
26) WINDY HILL 3	-	-	5	-	-	-
27) BADGER SLACKS	-	-	2	-	-	-
28) BOXING HOLE	-	-	2	-	-	-
29) URRA MOOR	-	-	25	-	-	-
30) WARCOCK HILL NORTH.	-	7	-	-	-	-
31) ROSEDALE	-	-	12	-	4	-
32) WARM WITHENS	-	-	-	-	-	3
33) OXY GRAINS BRIDGE	-	-	2	-	1	-
34) LYDSTEP HAVEN	2	-	-	-	-	-
35) SEAMER CARR	-	17	-	-	-	-
36) SEAMER CARR	16	-	-	-	-	-
37) S.W. MARCH HILL	-	3	1	-	-	-
38) MARCH HILL	-	9	-	-	-	-
39) MARCH HILL	-	3	-	-	-	-

table. 8

Recently, however, the chance discovery of a multiple-microlith find at Seamer Carr in the Vale of Pickering (David 1986) has provided a, thus far, unique opportunity for examining in detail the constructional characteristics of a microlithic tool. Some 17 triangles were found in a dual alignment on either side of remnants of a wooden shaft made of poplar. The microliths, exhibiting remarkable regularity and summetry in their design, were found to be sloping back as one might expect if they acted as barbs. Traces of the resin used in the hafting process were found to contain beeswax. A radiocarbon determination of 6600 ±150 b.c. on the wooden shaft clearly places this undoubted arrow within the earlier stages of the Later Mesolithic.

A number of interesting issues arise from the evidence considered so far. First, the association of microliths with the bones of hunted animals, and the instances where the original construction of microlithic tools has been preserved indicate the hunting role of microlithic technology during the Mesolithic. Beyond this, however, the evidence provides us with a limited view of the diversity in design which such projectiles may have taken. Whereas the Readycon Dene and Urra Moor finds indicate the uniseral hafting of large numbers of microliths onto very long shafts that are difficult to associate with 'arrow' technology, the cases from Seamer Carr and Risby Warren V would appear to indicate variability in the production of arrows. At Seamer Carr the 17 triangles were arranged in a dual alignment, whereas the Risby Warren V example might indicate a uniseral arrangement for the 8 triangles.

Furthermore, the finds from Readycon Dene (Rozoy 1978: fig. 265 i), Seamer Carr and Urra Moor (fig. 26a) demonstrate the degree of standardization, in terms of microlithic shapes and sizes, of the components being combined with individual tools. At Readycon Dene of the 35 microliths, all excepting one scalene triangle appear to be rhomboid microliths ranging between 10 mm and 19 mm.

in length. Similarly, at Urra Moor all of the 25 microliths are micro-rhomboids ranging between 14 mm and 8 mm in length. In addition, some 17 of these exhibit denticulated edges, a highly unusual feature for microliths in general.

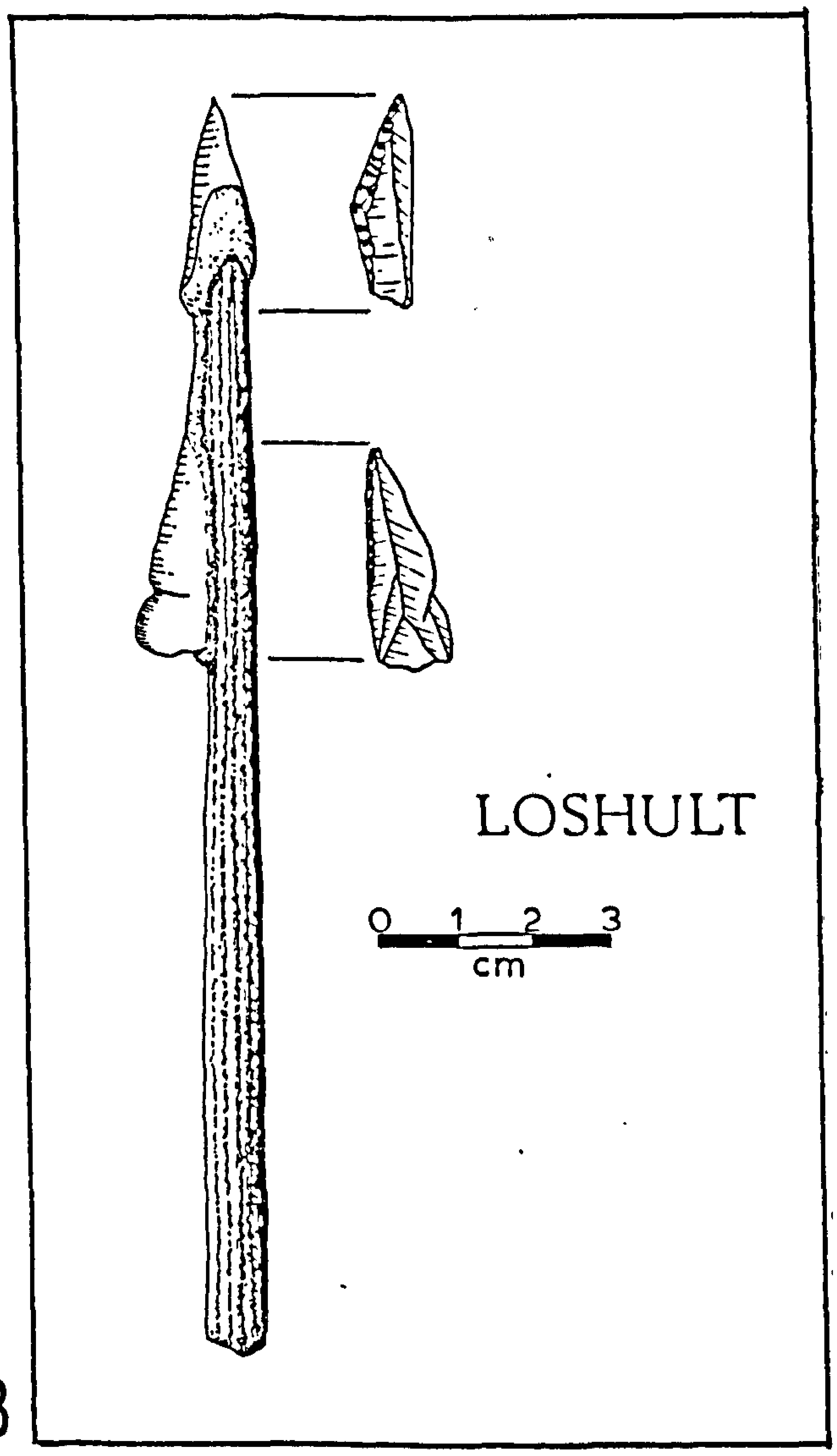
As noted previously, the arrow from Seamer Carr clearly illustrated the relationships of the individual microliths to the overall design of the tool. For the microliths acting as barbs their trailing edges were blunted, in contrast to their leading edges which appeared to be designed so as to offer the least resistance to penetration of a prey animal. Consequently, we gain a clear impression of an arrow designed to achieve maximal penetration combined with the least risk of the arrow pulling out from the wound. Taken together the use of microlithic hunting technology appears to have involved considerable care and consideration in overall design, layout and component manufacture.

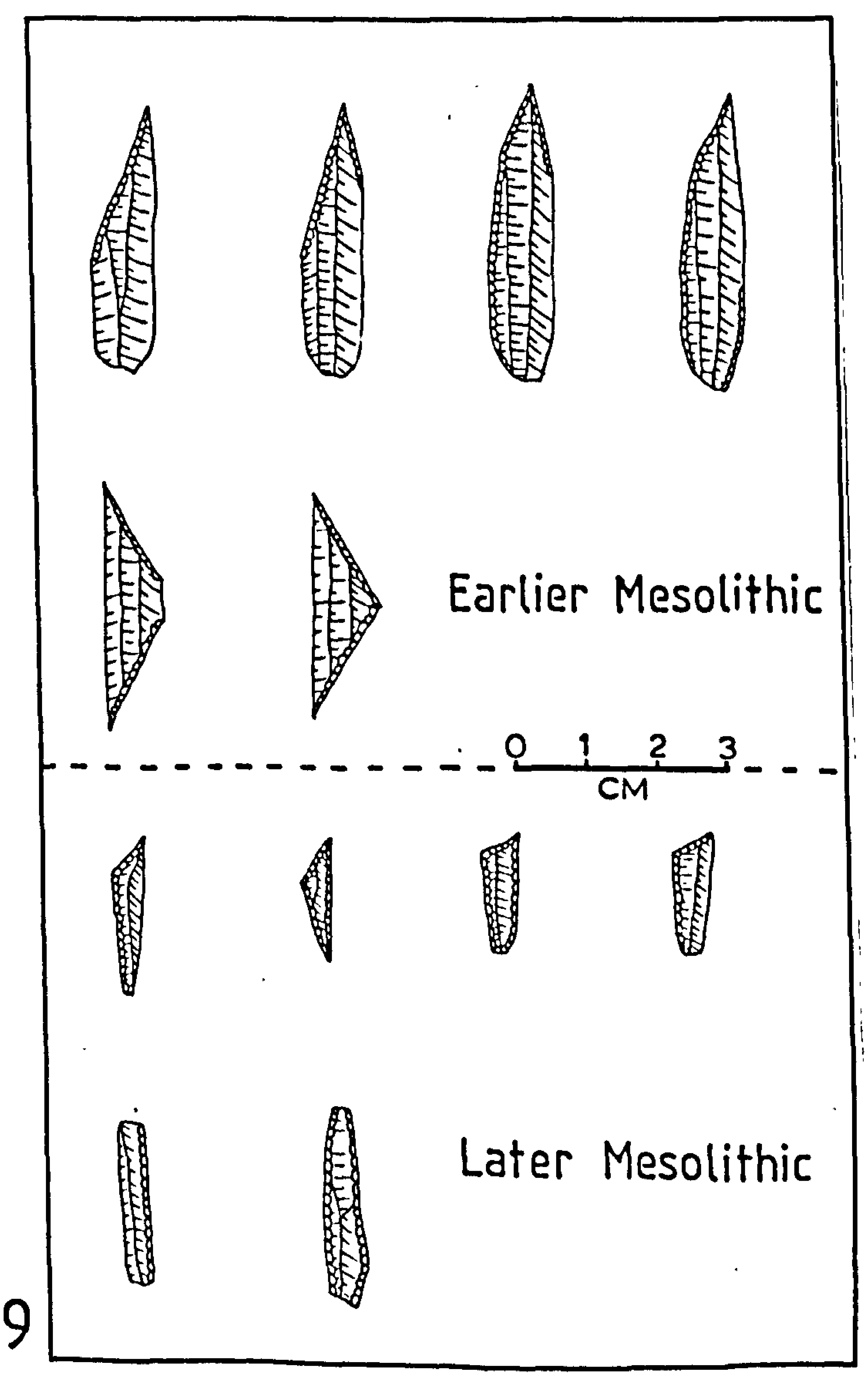
5) Earlier and Later Mesolithic microlithic tools

Of the evidence considered thus far none of the cases appear to relate to Earlier Mesolithic microlithic technology. In considering the relationship between Earlier and Later Mesolithic microlithic tools a great deal can be learned from the series of multiple-microlith finds, isolated from other forms of lithic debris, that are available to us (table 8). I wish to express my gratitude to Dr. R. Jacobi for drawing my attention to a number of such finds in his possession and for enabling me to have access to them.

A number of points are immediately apparent from the cases in table 8. It can be seen (fig. 27) that of some thirty-nine discoveries of 'more than one microlith' occurring in isolation from other lithic debris only one appears to represent an Earlier Mesolithic tool (Warm Withens - case 32) where some three non-geometric forms were found in association. All of the other cases appear to represent varieties of Later Mesolithic tools incorporating rods, triangles and rhomboids. It is clear that not all of these cases need refer to either complete or individual composite tools. The Earlier Mesolithic find from Warm Withens may represent a portion of a broken tool, whilst some of the other cases may derive from several tools or fragments of tools. Indeed, finds of microlith 'hoards', such as the discovery of over 80 microliths, all of Later Mesolithic types, at Beeley Moor in Derbyshire (Hart 1981: 32), or the discovery of over 100 rods and 2 scalene triangles at Pule Bents, West Yorkshire (Jacobi pers. comm.), have been excluded from table 8. Acknowledging these factors, however, would not explain or account for the fact that only one Earlier Mesolithic example has so far been recognized, whilst so many Later Mesolithic examples have been found.

Clues to the explanation for this comparative dearth of Earlier Mesolithic examples can be found in the numbers of microliths represented in these finds. We know, with some confidence, that the previously mentioned finds at Risby Warren V, Urra Moor, Readycon Dene and Seamer Carr point to the combination of numerous microliths within individual tools. All of these cases are Later Mesolithic in typology, with confirmation of a Later date in the radiocarbon determination from Seamer Carr. On typological grounds, the microlith-tool complexity data (table 8) appears to confirm that Later Mesolithic tools frequently incorporated six or more microliths, with many cases suggesting figures of between ten and twenty. The case from Warm Withens, and the absence of other Earlier examples strongly suggests that Earlier Mesolithic microlithic technology was less complex than Later tool forms, probably involving no more than three microliths per tool. Some confirmation of this conclusion may be found in the preserved Maglemosian arrows from Denmark, such as the finds from Loshult (Petersson 1951) where a complete microlithic arrow incorporating Earlier Mesolithic type microliths (fig. 28) clearly shows the use of just two (one as point, one as barb) microliths on the arrow.


LOSHULT
0 1 2 3
cm
fig.28


Earlier Mesolithic
0 1 2 3
CM
Later Mesolithic
fig.29

If it is accepted that Later Mesolithic microlithic tools employed, individually, more microliths than Earlier tools then we might conclude that the underrepresentation of Earlier examples reflects the lower likelihood of finds of two or three isolated microliths being noticed as being of any significance. Consequently, we are left with a clear impression of a pronounced change in microlithic tools between the Earlier and Later Mesolithic periods. In addition, there are grounds for suggesting that the Later Mesolithic saw the development of a range of microlithic projectiles, probably incorporating arrows and spears, which varied considerably in terms of the numbers of components (complexity) and in terms of the types of microliths being used on individual tools. Certainly, the impression of a high level of standardization in the shapes and sizes of microliths being combined on individual tools is confirmed by the cases in table 8 (fig. 27: see also Rozoy 1978: fig. 265 and Jacobi 1978a: 306). In this sense the find of 14 rods at Holiday Hill, North Yorkshire (table 8, no. 5) presents us with a remarkable example of the degree of symmetry achieved on certain tools - with an almost exact pairing-off of the rods in terms of lengths (Jacobi pers. comm.) suggesting a bilateral arrangement of barbs of equal paired sizes.

This evidence for the increasing complexity, high levels of standardization in design and construction, and diversity in form of Later Mesolithic microlithic hunting technology presents a series of explanatory challenges which will be discussed later. Of more immediate concern are the implications of these technological changes for discussions of Mesolithic industrial variability. It is now clear that the strong chronological component in both Mellars' (1976a) typology and the initial cluster analysis presented previously owes as much to the increased number of microliths being employed during the Later Mesolithic as it does any other behaviourally significant factor. The microlith-dominated 'type A' industries are largely a reflection of chronological changes in microlithic technology, as opposed to differential activity patterning during the course of annual subsistence schedules. This emphasizes the need for the initial separation of Earlier and Later Mesolithic tool assemblages prior to the formulation of 'assemblage types'.

Whilst there are no reasons for doubting the continuity of microliths as elements in hunting technologies the increased complexity and diversity of projectiles manufactured with microliths raises a series of questions about the analysis of microliths as tools. As discussed in chapter 2, there is a need to distinguish between tools and tool-components where it is suspected that certain retouched lithic forms may serve both as components and the principal focus of discard in the maintenance of tools. Such a distinction is crucial in considering the impact of variations in rates of curation upon inventories of retouched lithic pieces. It seems reasonable, for example, to suggest that microlithic projectiles were an object of curation during both the Earlier and Later Mesolithic periods. As such, the microlithic components of such projectiles cannot be assumed to be the objects of curation and, furthermore, are not tools in their own right. It follows that the depositional rates for microliths, contrary to the expectations for tools, may actually increase as curation rates for projectiles increase.

Two important implications for the analysis of Mesolithic industrial variability stem from the recognition of microliths as components and the the principal focus for replacement in the curation of projectiles. First, microliths must be treated separately from lithic forms that were themselves subject to reductive maintenance (i.e. axes, scrapers). Secondly, it can be argued that the increase in the percentage of total variability observed for microliths in the Later Mesolithic analysis represents an increased level of curation for projectiles during the period. Clearly, however, the latter suggestion takes no account of the increased rate of microlith deposition arising from the increased complexity of microlithic projectiles.

What emerges from this discussion is a clear picture of significant changes in certain key aspects of assemblage structure between the Earlier and Later Mesolithic incorporating an increase in the complexity and diversity of microlithic projectile technology. In place of the relatively simple arrows of the Earlier Mesolithic employing two or three microliths per tool the Later Mesolithic saw the manufacture of varieties of arrows and spears combining microliths, in both uniseral and bilateral arrangements, in complex arrangements of upwards of seven microliths per tool. In certain cases the multiple barb arrangements on such projectiles employed over twenty individual microliths. Within this increase in projectile technological complexity and diversity there is a clear impression of careful, standardized component design for individual tools. Finds of multiple microliths confirm this general impression (fig. 26).

6) Understanding Later Mesolithic projectiles

A number of authors have previously recognized certain aspects of the change in microlithic projectile technology during the Mesolithic (Jacobi 1978a; Mellars 1976a). In discussing the significance behind the replacement of the larger non-geometric microliths of the Earlier Mesolithic by an array of smaller geometric forms there has been a tendency to link these changes with the virtual disappearance of antler/bone projectiles during the Later Mesolithic. In considering Later Mesolithic microliths Mellars (1976a) suggested,

> 'Perhaps the most plausible explanation of these pieces ... is that they represent the insets for elongated, multiple-barbed spear-heads analogous to - and most probably replacing - those manufactured from bone and antler during the earlier stages of the Mesolithic.'
>
> (396).

Support for this interpretation was found in the apparent similarity in terms of shape and size of Later microlith forms with the barbs of Earlier Mesolithic bone points, and in the general impression of overall projectile design given by finds such as the Readycon Dene multiple-microlith discovery (Petch 1924: 29). Certainly, the spacing of the microliths noted for those multiple-microlith discoveries where the layout of the components has survived is broadly similar to the spacing of barbs on uniseral bone/antler points of the Earlier Mesolithic. As discussed in the previous sections it does seem likely that Later Mesolithic projectiles included elongated spears manufactured with multiple-microlith barbs in a uniseral arrangement.

However, two important observations on the character of Later Mesolithic projectile technology illustrate the inadequacy of explaining these industrial changes simply in terms of a direct functional replacement of antler/bone with lithics in association with spear manufacture. First, it is now apparent that the transition to geometric microliths was associated with the manufacture of both spears and arrows using complex uniseral and bilateral arrangements of microliths. Not only are bilateral barb arrangements not found with Earlier Mesolithic antler/bone points, but the changes are also reflected in Later Mesolithic arrow technology. In other words, the technological changes are reflected in projectile technology as a whole, and incorporate designs that are not found in the Earlier Mesolithic antler/bone projectile technology.

Secondly, although there may be a superficial similarity in the spacing and arrangement of barbs on Earlier Mesolithic bone/antler points and Later Mesolithic spears manufactured with microliths the similarity does not extend to the component complexity of such tools. In one sense, 'a barb is a barb' and can, therefore, be regarded as constant in functional terms. It has been argued (chapter 2), however, that in understanding the adaptational role of technology within a scheduling system dimensions of technological structure, such as tool complexity, carry important implications for our understanding of key design strategies - maintainability and reliability - which, in turn, inform us about time scheduling and stress. The replacement of spears in which the barbs, points and shafts are made from one component with spears made from separate components for barbs, points and shafts and which demand more complex hafting techniques (slotting, resin) clearly imposes a different set of manufacturing procedures, and presents alternative conditions for tool maintenance. Furthermore, the different raw materials demanded in the production of, on the one hand, antler/bone points and, on the other, microlithic spears involve changes in the relationships between raw material procurement and manufacture.

Taking the increased complexity of both arrows and spears together, and given the perspectives offered in chapter 2, it would appear that the Later Mesolithic saw a considerable shift towards the production of projectiles that were both maintainable and reliable. Maintainability is a reflection of the ease with which broken elements or components may be replaced. Earlier Mesolithic antler/bone points may be considered as maintainable in that the breakage of the tip of the point can be overcome through reshaping. However, the breakage of a barb on such a projectile cannot easily be overcome. In contrast, the breakage of microlithic barbs can be overcome through a replacement of the broken component with a fresh piece.

Reliability reflects the degree to which the failure of any individual component influences the functional effectiveness of the tool. Increased reliability is reflected in the 'building-in' of redundancy in components, where any component failure is compensated for by the presence of other components which assume the role of the broken component. By comparison with Earlier forms, Later Mesolithic arrows appear to incorporate a high level of redundancy for barbs, suggesting a shift towards reliability in arrow technology.

These trends in the design strategies of Mesolithic projectile technology suggest that the Later Mesolithic saw selective benefits associated with the manufacture of hunting weapons that were easily maintained and yet capable of effective functioning without repair. Such benefits might be expected under conditions where there was no reliable means of separating technological and subsistence hunting activity time allocations. In other words, the hunting technology had to be available for use at very short notice, and maintenance activities had to be amenable to unpredictable occurrences of free time for such activities.

An alternative, but largely complementary, perspective stems from the discussion of weapon complexity and time-stress in association with prey retrieval (chapter 2). It was argued that increases in weapon complexity might arise as a response to the need to limit time spent in retrieval of prey in order to reduce the risks of prey-retrieval failure. It might, therefore, be suggested that the Later Mesolithic resource environment imposed greater problems/risks in association with prey retrieval. Such changes may relate to the problems of tracking injured animals in wooded environments with dense understorey vegetation. At a more general level, the complex barb arrangements of Later Mesolithic projectiles may have enhanced the accuracy of weapons - with the noted concern for symmetry and/or careful component standardization - or extended the critical distance over which such weapons could be used. In this respect, it is interesting to note that the discovery of an Elk at High Furlong, Lancashire (Hallam et al. 1973) appears to represent the escape of an animal having been injured in a foreleg by a uniseral barbed point. The animal finally came to grief, uncaptured, in a marsh and subsequently came to rest in the late-glacial muds and silts in which it was unearthed. This chance find may have, in part, resulted from the limited range or accuracy of bone/antler point projectiles.

As discussed in chapter 2, increased complexity for food procurement technology may equate with increasing time-stress associated with subsistence activities. The observed increase in the complexity of Later Mesolithic projectiles may, therefore, be seen as a set of technological responses to increased time-stress in connection with hunting activities. Less certainly, the correlation between the diversity of food procurement technology and time-stress noted in chapter 2 may also be of some interpretative value. It might be expected that increased time-stress in association with hunting would offer selective advantages for the manufacture of a variety of task-specific weapons. Such specificity might take on various forms ranging from the design of projectiles for use on specific species to the design of projectiles for use under specific sets of hunting conditions. In any case, the use of tools designed for specific, anticipated conditions or contexts of use could represent a possible structural response to the need for maximizing time and minimizing the risks of hunting failure. However, despite the evidence for the manufacture of a variety of projectiles using microliths in different numbers and arrangements during the Later Mesolithic it is not clear if all of these variations represent an overall increase in the diversity of projectile technology.

First, we have, at present, a very limited understanding of variability in microlith projectiles for the Earlier Mesolithic. Furthermore, we cannot determine on present evidence the degree to which all of the variability in microlith projectiles during the Later Mesolithic represents task-specificity. To these doubts must be added the observation that some of the projectile variability during the Later Mesolithic may correspond to the replacement, in functional terms, of antler/bone points.

Nonetheless, the increased complexity and implications for projectile reliability and maintainability during the Later Mesolithic strongly suggests that both in terms of the organization and structure of hunting technology the Mesolithic witnessed significant changes that may be understood as responses to changes in the scheduling and time-stress characteristics of hunting. If, as has been widely assumed, hunting was an important, if not the most important, activity in Mesolithic subsistence activities then such changes must be potentially informative about some of the other observed changes in the Mesolithic archaeological record.

Technology

In the previous sections of this chapter much of the discussion has centred upon patterns of variability in the 'essential tool inventories' (sensu Mellars 1976a) of Mesolithic assemblages. Beyond the typological and tool assemblage changes which mark the Earlier to Later Mesolithic transition other characteristics of the lithic technology of the Mesolithic have been seen to change through time. In this section attention will be drawn to the existing evidence for changes in the patterns of flake/blade production and in the patterns of raw material use which coincide with the Earlier to Later Mesolithic transition.

1) Flake/blade production

For many years it has been generally acknowledged that variations in the typological content of Mesolithic tool industries correspond to differences in certain characteristics of the unretouched flake/blade industries. As long ago as 1924 Buckley, working in the upland Pennine region of northern England, sought to characterize these differences into a two-fold division - 'broad-blade' and 'narrow-blade'. Subsequent improvements in our understanding of the typological and chronological development of industries have enabled us to recognize that Buckley's broad-blade and narrow-blade industries correspond with the Earlier and Later Mesolithic periods respectively.

More recently, the analysis of the length/breadth characteristics of Mesolithic flake/blade industries (Pitts and Jacobi 1979) has confirmed that the dimensions of assemblages from the Earlier and Later Mesolithic periods do exhibit marked differences between the periods. In simple terms, the transition from the Earlier to Later periods appears to correspond with a shift away from the production of elongated, regular pieces towards the manufacture of shorter, broader flakes. As noted by Pitts and Jacobi (1979: 166), the terms employed by Buckley are potentially confusing since, in terms of length/breadth ratios, Earlier Mesolithic flake/blade assemblages are more narrow than are Later assemblages.

The work of Pitts and Jacobi confirms that the Mesolithic saw changes in not only the typology of stone tools but also in the length/breadth characteristics of debitage. At the time these observed changes in the debitage of Mesolithic sites were linked to changes in the patterns of raw material use which also appear to correspond with the Earlier to Later Mesolithic transition. In discussing the significance of these changes it was argued that one of the key causal factors in promoting the production of relatively shorter/broader flakes/blades was the increasing problems of acquiring high-quality raw materials. For the Mesolithic period these procurement problems were linked to the effects of rising sea-levels upon the availability of high-quality materials (Pitts and Jacobi 1979: 174).

2) Raw material use patterns

A number of authors have recognized that the Mesolithic saw changes in the patterns of raw material use. In the South-West Peninsula of England it has been recognized (Jacobi 1979a; Pitts and Jacobi 1979) that there was a change from the widespread usage of high-grade translucent flints ranging in colour from honey brown to black during the Earlier Mesolithic towards the use of low-grade beach flint and cherts from the Blackdown and Haldon regions. In the Earlier period Blackdown chert use was confined to sites in the source's immediate vicinity, whereas the material appears on sites throughout the South-West Peninsula during the Later Mesolithic (Pitts and Jacobi 1979: 174-5). Similarly, the use of Cretaceous chalk flint, derived from eastern sources, only appears in assemblages from the east of the Peninsula during the eighth millenium b.c. (Jacobi 1979a: 76).

For the south of England it has been noted (Care 1982; Pitts and Jacobi 1979) that whereas in the Earlier Mesolithic flint derived from the chalk dominated assemblages the Later Mesolithic saw a pronounced shift towards the use of low-grade river gravel flint (i.e. Kennet valley, Berkshire) and Greensand cherts.

In northern England it has long been recognized (Buckley 1924) that many of the 'broad-blade' (sensu Buckley) industries of the Pennines were dominated by the use of a distinctive opaque, mottled-white flint. It is widely accepted that this flint derives from the Cretaceous chalk outcrops in East Yorkshire and North Lincolnshire (Mellars 1973; Radley and Mellars 1964: 8). During the Later Mesolithic, however, Pennine assemblages incorporate a wide range of translucent and semi-translucent coloured flints, black chert, and a range of other Pennine cherts of varying qualities. Furthermore, these changes in raw materials are also reflected in assemblages from the Lincolnshire Edge (Jacobi 1978a: 303) where the white flint is replaced by varieties of translucent and semi-translucent flints as the dominant material.

Whilst the rising sea-levels of the Mesolithic almost certainly gave rise to the loss of access to certain raw material sources it seems remarkable that the effects of these changes in supply should have influenced raw material use throughout England in such a contemporaneous fashion. Furthermore, it is difficult to see why rising seal-levels should have limited access to the chalk flints of southern and northern England, unless one argues that easily accessible supplies of such material happened to 'run-out' at the same time that sea-levels were denying access to other sources.

One further problem in the explanation of these changes lies in the characterization of different raw materials as being high or low grade. Whilst many of the cherts exploited during the Later Mesolithic may be justifiably regarded as mechanically inferior to flint won from the chalk this does not necessarily apply to all of the cherts, and certainly cannot be applied to many of the translucent flints that were used in the Later period. Indeed, some of the Earlier Mesolithic assemblages from northern England are dominated by tranlucent flints (Star Carr, Warcock Hill South, Pointed Stone 2 and 3) that are clearly of a high quality. Such material is also found in certain Later Mesolithic assemblages in the Pennines (Rocher Moss 2), and although these materials may differ in terms of their sources there are no obvious grounds for suggesting that the material at sites such as Rocher Moss 2 is mechanically inferior.

What emerges from these observations is that the transition from Earlier to Later Mesolithic industries is widely associated with changes in the patterns of raw material use. Within these changes it is possible to recognize moves towards the usage of a diverse set of lithic sources encompassing raw materials of considerable variability in mechanical properties. The reasons for these and the other, previously identified, changes in technological organization and structure cannot simply be attributed to physical changes in the availability or accessibility of high-quality materials.

If we look beyond explanations for the differences in raw material use between the Earlier and Later Mesolithic periods and focus attention upon perspectives dealing with the interpretative significance of raw material distributions a number of significant points emerge. There are a number of instances where the distinctive visual appearance of specific raw materials has enabled authors to discuss, in sometimes very general terms, the relationships between raw material representation in assemblages and the distances from raw material sources or source areas. One such instance is provided by the long-standing recognition of the occurrence of Portland chert, a highly distinctive opaque blue-black material, on Mesolithic sites widely dispersed throughout southern England (Rankine 1951; Palmer 1970b). Although it is possible that some of this distinctive material originated from limited outcrops of the Purbeck limestone inland, or from material in beach deposits, there are good reasons for suggesting that the major source of Portland chert were the exposures on the cliffs of the Isle of Portland itself.

Recognition of the widespread distribution of this material during Mesolithic and later prehistoric periods led Rankine (1951) to suggest that this indicated 'migrations or barter from Mesolithic to Bronze Age times.' (93). Similarly, Palmer (1970b), in drawing attention to the extensive distribution of Portland chert during the Mesolithic, echoed Rankine in suggesting,

> 'This indicates folk-movement or barter of varying orders at an early post-glacial date.'
>
> (101).

Less cautiously, Bradley (1970) drew attention to the distribution and attributed the dispersal of this material to 'trade in Portland chert and in other stones from the south-west.' (16). Since then the mechanisms through which Portland chert achieved a widespread distribution have increasingly been discussed in terms of trade or barter (Bradley 1984: 12; J.G. Evans 1975: 104; Jacobi 1979a: 74, 1981: 19; Orme 1979: 198). Admittedly, there is good evidence for the movement of a range of materials to and from the South-West Peninsula which appears to link large areas of southern England (Jacobi 1981: 18 - 9). Furthermore, there are grounds for suggesting that certain tool forms, most notably axes (Care 1979), were produced in certain regions and dispersed to others.

The problem remains, however, of adopting analytical approaches to the distributions of materials such as Portland chert that would assist in distinguishing between the mechanisms of 'migration or barter'. Whilst the numbers of Mesolithic sites where Portland chert has been found has increased since Rankine (1951) made his initial observations the various statements that have been made concerning the significance of the distribution and the mechanism(s) responsible have not employed any new approaches and remain founded upon the same arguments as those made by Rankine (1951, 1961a).

This absence of analytical criteria for distinguishing between the various possible mechanisms acting in the distributional patterns of raw materials during the Mesolithic is reflected in the arguments applied to raw material patterning in northern England. As noted previously, it has long been recognized that many Earlier Mesolithic sites in the upland regions of northern England have lithic assemblages dominated by flint derived from distant lowland sources, Radley and Mellars (1964) drew attention to the dominance of white flint at the Pennine site of Deepcar and commented,

> 'The dominance of one flint type suggests that the toolmakers had contacts primarily with the east, where the white flint is found in the east Yorkshire chalk.'
>
> (8).

The question arises, what was the nature or mechanism(s) of such contacts? In observing the same pattern of dependence upon white flint for sites in the Pennines and sites close to the sources of this material Jacobi (1978a: 304) commented that,

> 'what we may be witnessing in the case of this white flint is its direct collection by groups exploiting the Pennine uplands in summer from established quarries or exposures in ... the same areas which ... could have served as optimum wintering grounds. The presence of isolated flakes of Pennine chert on sites along the Lincolnshire Edge and in Hatfield Chase might be seen as confirmation of such annual movements.'.

Here, then, we see the distribution of the white wolds flint, in combination with observations on the distribution of Pennine cherts, being interpreted as evidence for the sort of seasonally based upland-lowland mobility model put forward by Clark (1972). The high level of dependency upon wolds flint noted for sites some 80 - 100 km from the raw material source is seen as a product of the mobility scale of the groups involved, whilst the same arguments are applied to the occasional finds of Pennine chert in assemblages distant from the Pennine raw material sources. Although this interpretation moves some way towards a more explicit view of the procurement mechanism(s) involved there is still an absence of any clear statement of why these distributional patterns should be interpreted as products of migration as opposed to other possible mechanisms.

The same interpretation as that applied to the wolds flint assemblages has also been applied to assemblages made from translucent and semi-translucent flint which also occur in lowland and upland contexts in northern England during the Earlier Mesolithic (Jacobi 1978a: 305 - 307). Given that the distributions of these materials have been seen as potentially informative concerning the mobility scale of Earlier Mesolithic groups there is a clear need for the adoption of analytical approaches that would help to clarify and distinguish between the various potential procurement mechanisms involved. Similarly, the attention given to the Portland chert distribution and the potential interpretative significance of identifying a 'gift-exchange system' (Jacobi 1978a: 304) in Mesolithic contexts demands the development of explicitly developed models with testable archaeological implications that would assist in discriminating between different mechanisms of procurement.

Although the comparative dearth of clearly developed approaches to the interpretation of Mesolithic raw material distributions may be, in part, attributable to the apparent absence of recognizable quarry locations/ production sites from which such studies might proceed there may be a more fundamental reason for this state of affairs. Without a clearly developed theoretical framework within which to examine lithic procurement patterns the study of such evidence will remain a secondary line of enquiry. The traditional analytical framework based upon typological/stylistic attribute comparisons will continue to provide the primary argumentative basis for integrating regional lithic data sets within subsistence/mobility models which, themselves, have been developed largely under the influence of the Clark (1972) model for Star Carr. Given that the Clark model can now be, at least, doubted the need for fresh approaches to inform us about Mesolithic behaviour is reinforced.

As a final testimony for the need to adopt approaches enabling lithic procurement patterns to play a primary role in our understanding it is interesting to note that recent work within the typological/stylistic paradigm (Jacobi 1978c, 1979a, 1980b, 1981) has suggested that the Later Mesolithic period saw the increased regionalization of microlithic styles. Whilst this thesis has deliberately avoided any detailed discussion of the stylistic paradigm it is acknowledged that such approaches (Gendel 1974) must continue to provide important lines of argument and evidence in the study of the period. As our theoretical understanding of stylistic parameters develops (Plog 1983; Sackett 1977; Wiessner 1977; Wobst 1977) opportunities may arise for an integration of approaches within a broader theoretical framework. The increasing regionalization of microlithic styles may well inform us about long-term trends in social interaction which will, in turn, carry implications for mobility, scheduling behaviour and patterns of lithic procurement (see Pitts and Jacobi 1979: 174 - 176). The important point here is that the development of such patterning during the Later Mesolithic once again serves to emphasize that the Earlier and Later Mesolithic periods show marked contrasts in archaeological evidence and require separate consideration and modelling. Quite apart from the inadequacy of applying the Clark model of seasonal mobility and resource procurement to Later

Mesolithic contexts the evidence for changing technology, settlement sizes and distributions, and the arguments put forward previously in this chapter for changing conditions of resource procurement between the Earlier and Later Mesolithic demand that attention be given to developing approaches designed to inform us about the significance of these changes.

Discussion

In reviewing the economic, settlement and technological evidence for the Mesolithic period it has been argued that the transition from the Earlier to Later Mesolithic periods saw fundamental changes which are reflected in the archaeological record. Whilst the direct economic evidence is limited in both quantity and quality, and biased spatially and chronologically there are sufficient grounds for doubting current models for subsistence behaviour during the period. In particular, the highly influential model of seasonally based mobility and subsistence activity developed by Clark (1972) has been argued to contain severe shortcomings both in terms of the seasonality indicators for Star Carr and in the overall integrative model portraying Earlier Mesolithic activity. An alternative interpretation has been offered which, it is believed, represents a more appropriate perspective of the evidence at Star Carr and carries important implications for the subsistence, settlement and mobility patterns of the Earlier Mesolithic. Central to this new model is the suggestion that Earlier Mesolithic hunting strategies varied during the course of the year. During the spring and summer months the subsistence activities of Earlier Mesolithic groups were focussed upon low-lying regions where generalized procurement strategies were undertaken. During this time hunting followed the general patternsdescribed as encounter hunting, and was generalist in character.

With the onset of autumnal conditions came a shift towards specialist intercept strategies which were undertaken in and around the confines of upland valleys. These strategies enabled the storing of sufficient quantities of meat, principally from Red deer, to be undertaken, which, in turn, provided the necessary basis for over-wintering in lowland sites without resorting to high-risk strategies of dependence upon winter-hunting. Incidental to, or embedded within this autumnal strategy was the procurement of large quantities of antler which was lightened, transported to lowland sites and used for industrial purposes.

In terms of settlement patterns the new model of Earlier Mesolithic activity can be seen to conform to the expectations for a collector system (sensu Binford). The intensive hunting of deer during the autumn, combined with a heavy dependency upon logistically organized mobility, food storage for over-wintering, and the implications for high levels of environmental redundancy would agree with the general picture of settlement during this period. Sites tend to be larger, and located in a relatively restricted set of locations suggesting, within this model, the expected pattern of site re-occupancy and locational fixedness so typical of collector systems. It is significant to note that a number of the larger Earlier Mesolithic sites have produced clear stratigraphic evidence for repeated occupations (Star Carr, Oakhanger V and VII, Thatcham, Downton), and that similar evidence has also been claimed from the smaller site of Unstone 1 (Courtney and Pierpoint n.d.).

a) Implications of the Earlier Mesolithic model

Within the model outlined above arise several important test implications for the regional archaeological record. First, the strategic and adaptational importance of over-wintering on the basis of stored foods from an autumnal intercept strategy must have imposed several organizational demands upon technology. As noted previously, one of the key conditions for successful intercept hunting lies in the preparedness of the hunting technology. Such 'gearing-up' would not have been undertaken at the time of the hunt, but would have been scheduled in order to ensure that manufacturing time did not conflict with hunting time.

The anticipatory 'gearing-up' of hunting technology associated with an intercept strategy would be expected to contrast markedly with organizational and scheduling demands of more generalized encounter strategies. Whereas under the former conditions the predictable locational and temporal demand for large quantities of hunting equipment would produce intensive anticipatory manufacture, encounter strategies would, through the increased uncertainty of the quantity, timing and locational demands upon technology, demand different organizational strategies for projectile production. The emphasis might be expected to shift towards the maintenance of a given level or quantity of projectiles available for use at any given moment. Consequently, whereas intercept strategies would be preceded by the manufacture of additional projectiles, encounter strategies would be reflected in a steady maintenance/replacement of existing projectiles.

In terms of time-stress and resulting implications for scheduling the contrast between the autumnal intercept and spring/summer encounter strategies will also be pronounced. Given that the autumnal hunt would represent a crucial element in the over-wintering strategy it may be expected that the greatest need for efficiency in the reduction of failure risks would be associated with the autumnal intercept strategy. Technologically, such efficiency-demands might result in the selection of projectiles most suited to the task. In contrast, the generalist strategies of the spring and summer might be expected to be less efficiency-stressed in that they incorporate a range of low-risk, low-return activities (plant-foods, fishing, fowling) in addition to the inputs from encounter hunting. Consequently, the encounter hunting strategies might be, themselves, less efficiency-stressed and involve projectiles reflecting this reduced level of stress.

The contrasting organizational and time-stress characteristics of intercept and encounter strategies in the proposed model carry a further set of implications that are potentially significant archaeologically. As discussed in chapter 2 the role of embedded strategies of lithic procurement achieves the most significant position within technological strategies of hunter-gatherers operating in conditions where there are selective benefits to be gained from segregating time allocations for technological and subsistence activities. Embedded lithic procurement produces a steady input of raw materials which reflects the scale of subsistence mobility as a result of the availability of spare transport (carrying) capacity following task-group activities. If, however, the patterning of subsistence activities produces variability in the incidence of such spare transport capacity then the locations where such subsistence activities producing low frequencies of these incidences are undertaken will be under-represented in terms of embedded lithic inputs from such locations. Clearly, these potential biasing effects will reflect the scale and regularity of transportable subsistence products occurring in association with task-group subsistence procurement mobility.

In terms of the Earlier Mesolithic model we might expect the greatest consistency in the scale and regularity of transportable subsistence products arising from task-group organized subsistence procurement to be associated with the time-stressed, efficiency-stressed hunting of the autumnal period. The specialized, intensive, and anticipatory intercept strategies of autumn will have produced large quantities of subsistence products in a relatively short time. These products will have demanded temporary field caching and subsequent collection and transportation to over-wintering sites. Consequently, little time or spare transport capacity will have been available for secondary lithic inputs - visiting lithic sources, transporting nodules/cores - and will have resulted in an under-representation of lithic materials from sources in the area. The reduced incidence of time and energy for embedded lithic procurement will have been reinforced by the coincidental availability of large quantities of antler as an immediate by-product of the hunting. The availability of this alternative raw material for technology ensured that any spare transport capacity was devoted to antler transportation.

By the same reasoning, encounter strategies of hunting undertaken as part of a generalist, low efficiency-stressed subsistence regime during spring and summer will have produced, both in terms of scale and regularity, less in the way of transported subsistence products. From this it follows that the spring and summer periods will have witnessed more regular and frequent embedded inputs. This, combined with the greater total duration of the spring and summer in comparison with the autumn, will have served to ensure that the areas occupied for spring and summer hunting will be heavily represented, in terms of raw materials, within lithic assemblages in all regions occupied as part of the annual subsistence cycle.

b) Contrasting implications for the Later Mesolithic

In certain respects the poverty of adequate economic data for the Later Mesolithic has rendered our models of behaviour for this period as 'the poor relative' of the Earlier Mesolithic. All too frequently it is possible to detect the rationale of the Clark (1972) model underpinning interpretations of Later Mesolithic subsistence and mobility. The observed changes in tools, technology, settlement sizes and locations, and raw material use, quite apart from the evidence for the changing environmental context between c. 7000 and 6000 b.c., should warn against assumptions of behavioural continuity and emphasize the need for considering the implications for behavioural change between the Earlier and Later Mesolithic.

If, as was argued previously, one of the major impacts of the environmental changes which occurred during the seventh millenium b.c. was the shift in selective pressures acting upon herbivore migratory and distributional behaviour then the increased benefits of non-migratory strategies during the Late Boreal and Early Atlantic periods may have presented a new set of resource procurement problems for hunting. The loss of locationally and temporally predictable animal concentrations in areas where intercept strategies could be profitably employed must have carried far-reaching implications for subsistence scheduling and particularly for strategies of over-wintering. In place of over-wintering with stored resources from intensive autumnal hunting Later Mesolithic populations may have been obliged to adopt a more active resource procurement strategy during the winter period. The high risks associated with such a 'hand-to-mouth' strategy based upon hunting have already been stressed. The risks would have been increased if such hunting was pursued through encounter strategies.

For some populations one option available for reducing levels of risk during winter may have been the exploitation of low-risk, low-return resources whose locational characteristics rendered them as 'passively-stored' resources. The evidence for winter shellfish gathering at Morton Tayport B (Deith 1983) may provide evidence for such a strategy. In other contexts attempts at the introduction of artificially encouraged game concentrations, either through selective burning or fodder collection, might be interpreted as strategies for increasing the productivity or reducing the risks of failure of hunting. The evidence for the increased complexity, diversity (?), maintainability and reliability of Later Mesolithic projectiles would accord well with a set of responses designed to reduce the risks of failure associated with hunting, and especially if such hunting was primarily pursued through encounter strategies.

The loss of opportunities for exploiting spatially and temporally predictable game concentrations through intercept strategies, combined with the general shift amongst animal populations to more stable, dispersed distributions will almost certainly have presented a new set of resource procurement challenges for Later Mesolithic populations. If it is accepted that settlement patterns are responsive to changing environmental resource conditions then the evidence for smaller site sizes and greater variety and dispersal of site locations during the Later Mesolithic may, in part, reflect the changing strategies for hunting. In place of the logistical strategies of the Earlier Mesolithic, where resources were transported to consumers through task-group mobility, the Later Mesolithic settlement evidence may reflect a shift towards moving consumers to resources. Such a change in mobility patterns would demand higher levels of residential mobility, possibly involving smaller residential group-sizes and shorter periods of residential site occupancy. The reduced levels of spatial and temporal incongruency amongst game populations within an environment where primary production was still seasonally variable may have promoted reduced levels of environmental redundancy in settlement patterns as human groups maintained a dispersed and more mobile set of residential strategies. Within such a system the need to reduce the risks of hunting could be expected to be largely dependent upon technological responses. This is not to say, however, that naturally occurring contexts offering greater chances of hunting success would be ignored. In regions where surface water sources are spatially discrete and relatively few in number (i.e. upland limestone regions) water-holes or springs might be expected to attract local game populations and present hunters with improved conditions for anticipating the appearance of animals. That such patterns may be reflected in the Carboniferous Limestone region of North Derbyshire during the Later Mesolithic has already been indicated.

If the reasoning thus far employed is broadly correct then it is possible to identify certain additional implications for the Later Mesolithic archaeological record. In terms of lithic procurement the more widespread adoption and increased dependency upon encounter hunting strategies will have produced more regular and spatially undifferentiated opportunities for embedded inputs. From this we might expect to see a closer approximation between the spatial distribution of food resource procurement activities and the lithic raw material content of assemblages. That such embedded inputs were more regularized and evenly distributed throughout the annual subsistence schedule may have been crucial to the organization of projectile manufacture and maintenance. The loss of anticipatory structuring in the locational and temporal hunting schedule within a system where hunting provides a crucial element in dietary strategies must present organizational problems in the scheduling of projectile-related technological activity. In the absence of any clear and predictable means of segregating technological and subsistence time allocations the benefits of securing raw material inputs throughout the annual subsistence cycle in order to ensure that technological activity can be undertaken when and where time is available for such activity must be considerable.

Arising from the previous point, it might also be noted that the lower levels of spatial redundancy in settlement patterns combined with the higher levels of residential mobility would serve to introduce additional problems in the variability of raw material mechanical properties. Although embedded inputs of lithic raw materials may periodically have included high quality materials such inputs may have been increasingly unpredictable. Inputs from poorer quality sources may have influenced the design of projectile components even though higher quality materials were periodically available.

Given the emphasis upon being able to maintain projectiles through the replacement of components whilst maintaining the broad symmetry or similarity of components it may have proved necessary to ensure that such components could be manufactured from poorer quality materials. Such precautionary design limitation may account for some of the typological differences in microlith designs between the Earlier and Later Mesolithic. It has already been noted that in comparison with Earlier forms Later Mesolithic microliths are noticeably smaller. The technological differences between Earlier and Later Mesolithic microliths are, however, more subtle than simple differences in size. In general terms it can be seen (fig. 29) that Earlier microlith types are designed very largely around the dimensional and shape characteristics of blades with regular, parallel margins. Large obliquely-blunted points and elongated trapezoids retain many of the shape characteristics of elongated, regular blades. In contrast, Later Mesolithic microliths show a greater dependency upon retouching in producing their final shapes. In other words, they are less dependent upon the production of elongated, parallel sided blades for their final design characteristics.

The change in Mesolithic flake/blade debitage characteristics noted by Pitts and Jacobi (1979) may, therefore, represent technological accommodations to the lower-quality raw material inputs and reduced predictability of high-quality raw material inputs arising out of the changing settlement and mobility patterns, changing embedded inputs, and increasing demands for maintainable, complex projectiles within a system where technological and subsistence schedules could not be effectively segregated.

c) <u>Considerations for a case study</u>

In seeking to examine the appropriateness of the perspectives offered for the Earlier and Later Mesolithic a number of prerequisites in terms of the archaeological record may be identified. These prerequisites provide the basis for selecting a region offering the greatest opportunities for addressing the various issues arising from the discussion of Earlier and Later Mesolithic behaviour.

First, in selecting a region for examination, ideally, the chronological sequence and typological distinctions between the Earlier and Later Mesolithic should be well established. It should be apparent from chapter 3 that the degree of chronological and typological control for the Mesolithic is highly variable between regions. Of the various regions discussed the north of England would appear to offer the most suitable conditions. Both in terms of absolute chronology and typological development our understanding of the Mesolithic in northern England would seem to offer the most secure data-base.

Secondly, in order that the organization of lithic technology at a regional level can be examined in terms of changing patterns/mechanisms of lithic raw material procurement the archaeological record must a) exhibit clear changes in raw material usage, and b) offer opportunities for relating raw materials in assemblages to distances from source-areas. Whilst many regions exhibit the former precondition, the north of England would appear to provide the best opportunity for identifying and associating different raw materials with specific source-areas. Certainly, in terms of well documented assemblages the north of England provides relatively good coverage, although the quality and quantity of the archaeological record may be variable within the region.

Thirdly, given the significance attached to changes in the hunting strategies of Earlier and Later Mesolithic populations, and the significance of upland and upland valley locations for the postulated Earlier Mesolithic autumnal intercept strategy the region selected should contain clear intra-regional variability in relief and altitude. Once again, the north of England offers a clear division between the upland Pennine and North York areas, and the more low-lying regions surrounding these upland areas. Taking all of these conditions into consideration it appears that, as a region, the north of England should offer the necessary prerequisites for examining the perspectives offered for the Earlier and Later Mesolithic.

Chapter Five:

The Mesolithic of northern England: a case study

1 Description of the study area

The region selected as the study area exhibits considerable topographic and geological variability. The west of the study area (fig. 30) includes the dissected upland plateau of the Pennines with summits of over 2000 ft. (610 m) above sea-level. Running north-south along the western boundary of the study area the Pennines separate the low-lying regions of the Cheshire and Lancashire Plains in the west (not included in the study area) and the Vales of Mowbray and York, as well as the Trent valley, in the east. As such, the Pennines have been referred to as 'the back-bone of England' (Edwards and Trotter 1954: 1).

In terms of drainage patterns the Pennines are dissected by a series of rivers (fig. 31) running down from the central watershed into the low-lying regions to the west and east. The western boundary of the study area runs slightly to the west of the major watershed formed by the principal rivers. Consequently the study area includes both the principal watershed and major drainages running eastwards from the Pennines. In the south-western corner of the study area the more southerly orientation of drainages reflects the southern margin of the Pennines formed by the Derbyshire Peak.

Geologically, the Pennines are formed by a series of formations monoclinally tilted towards the east. The major strata which form the Pennines (fig. 32) consist of Carboniferous limestone and millstone grit, with some coal measures deposits. The upland Carboniferous rocks fall into three general regions. The northern region is occupied by the limestone and 'Yoredale Series' (beds of shales, limestones and sandstones) of the Yorkshire Fells and the Askrigg Massif (Edwards and Trotter 1954: 1 - 3). The Central Pennine region is occupied by millstone grits and coal measures, whilst the Southern Pennines and Derbyshire Peak regions are formed of continuations of these deposits with the addition of the limestone Massif of the Derbyshire Peak (Millward and Robinson 1975). From this it can be seen

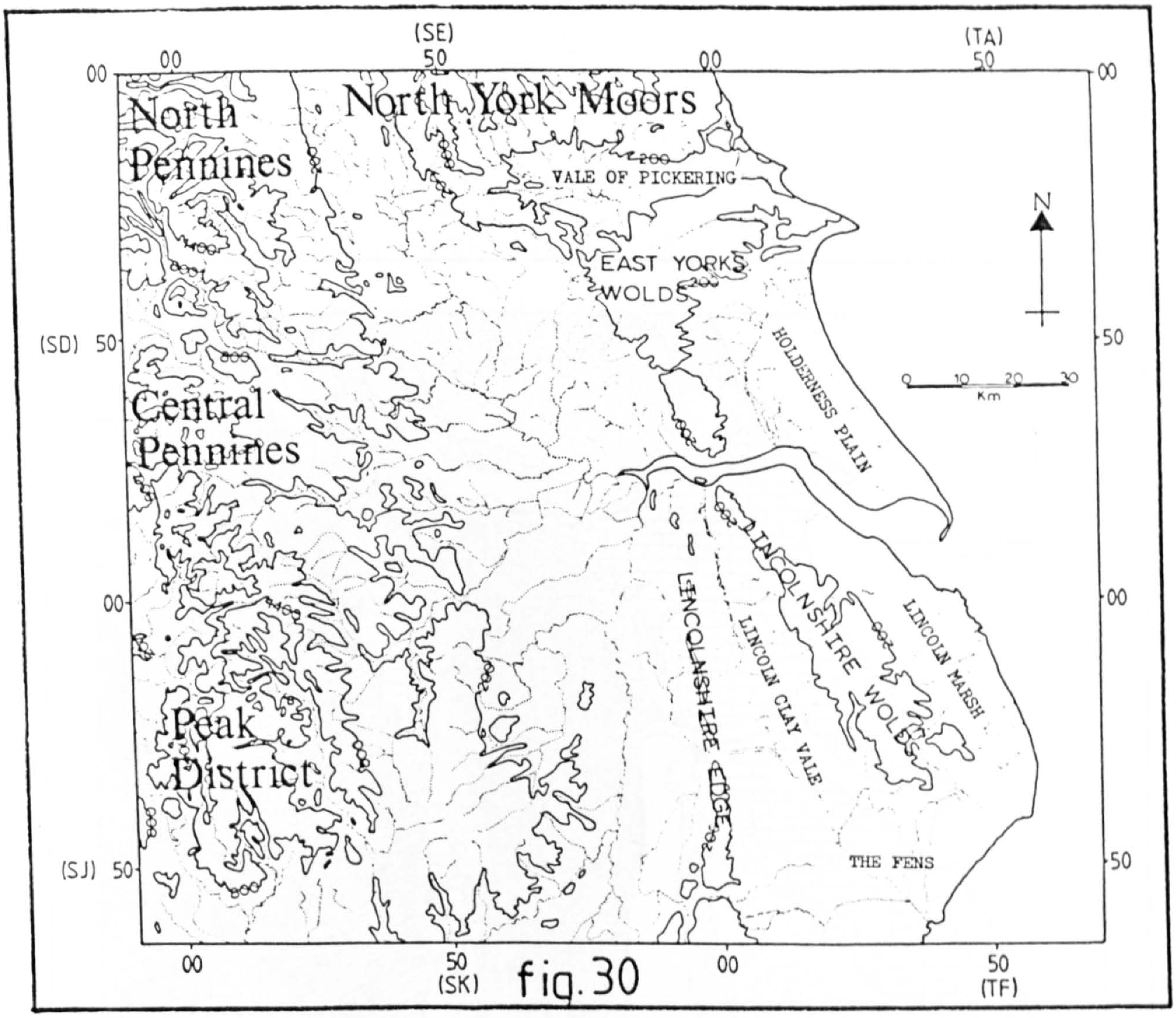

(SE)
(TA)
(SD)
(SJ)
(SK)
(TF)
North Pennines
North York Moors
VALE OF PICKERING
EAST YORKS WOLDS
HOLDERNESS PLAIN
Central Pennines
LINCOLNSHIRE WOLDS
LINCOLNSHIRE EDGE
LINCOLN CLAY VALE
LINCOLN MARSH
Peak District
THE FENS
N
0 10 20 30
Km

fig.30

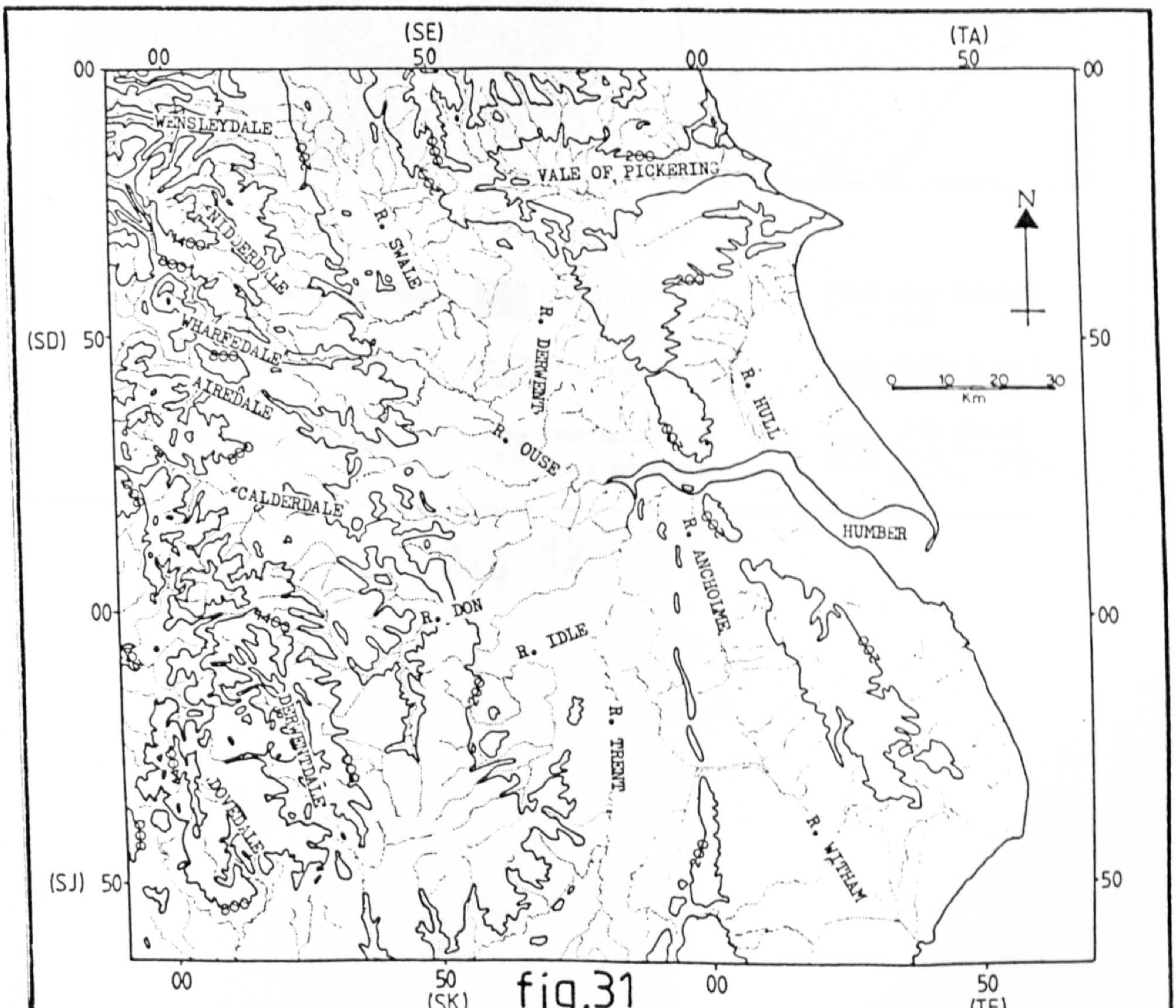

(SE)
(TA)
(SD)
(SJ)
(SK)
(TF)
WENSLEYDALE
VALE OF PICKERING
NIDDERDALE
R. SWALE
WHARFEDALE
R. DERWENT
R. HULL
AIREDALE
R. OUSE
CALDERDALE
HUMBER
R. ANCHOLME
R. DON
R. IDLE
R. TRENT
DERWENTDALE
DOVEDALE
R. WITHAM
N
0 10 20 30
Km

fig.31

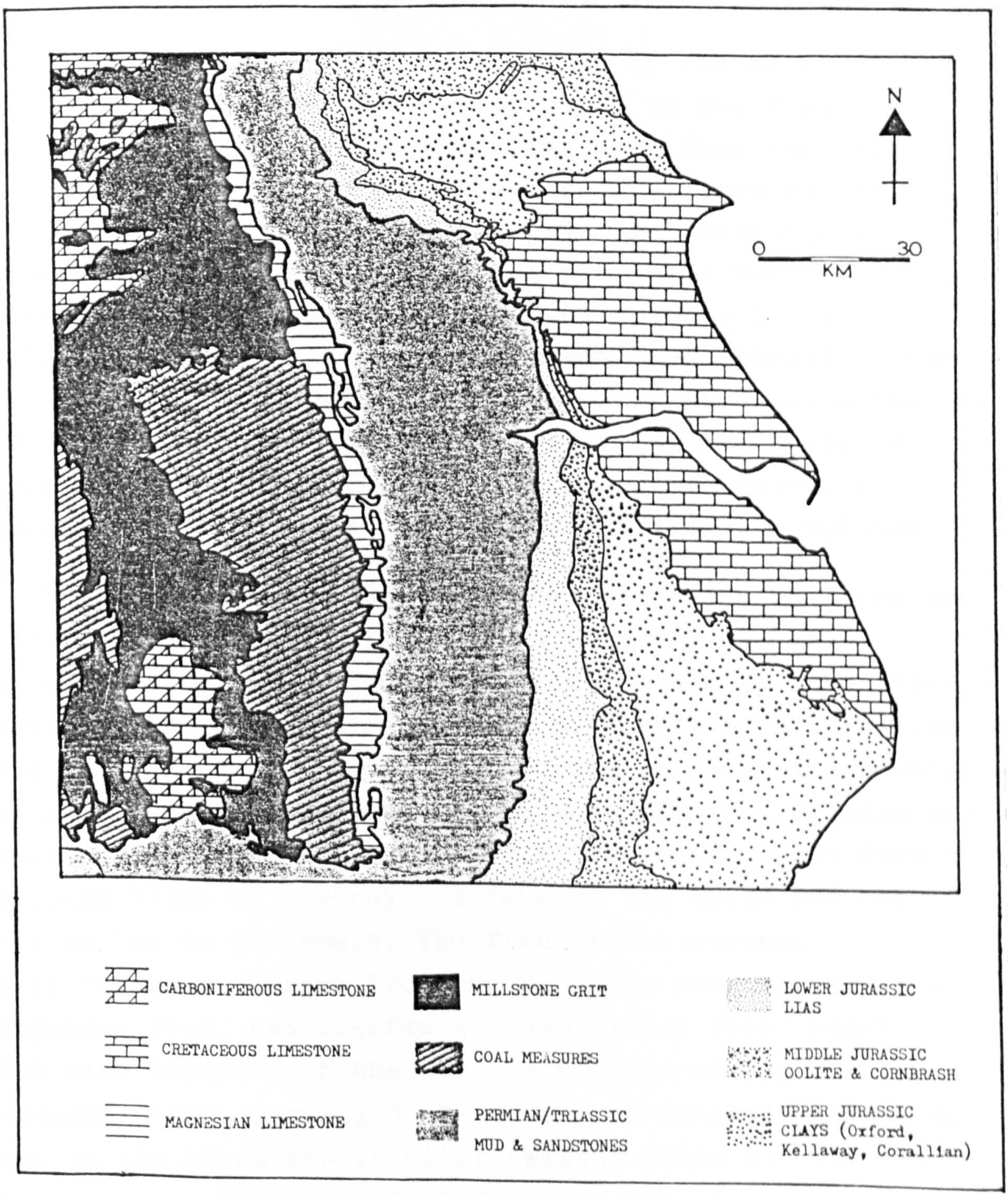

N
0
30
KM
CARBONIFEROUS LIMESTONE
CRETACEOUS LIMESTONE
MAGNESIAN LIMESTONE
MILLSTONE GRIT
COAL MEASURES
PERMIAN/TRIASSIC MUD & SANDSTONES
LOWER JURASSIC LIAS
MIDDLE JURASSIC OOLITE & CORNBRASH
UPPER JURASSIC CLAYS (Oxford, Kellaway, Corallian)

fig. 32

that the limestones of the Askrigg Massif and the Derbyshire Peak are two physically distinct formations (Hey 1956; Shirley and Horsfield 1940; Wells 1955).

Throughout the Pennines dissection by the major rivers and the various tributaries has resulted in the formation of a complex of small valleys leading down from the upland summits which combine to form the larger valleys running down into the lowlands. Where the principal drainage is west-east this has left a series of prominent valleys leading more or less directly from the uplands to the low-lying ground to the east of the Pennines. Amongst these we may include Wensleydale, Nidderdale, Wharfedale, Airedale, Calderdale and the Don valley (fig. 31). At the southern margin of the Pennines the major dissectional features, Derwentdale and Dovedale, run southwards from the uplands.

To the east of the Pennines the Carboniferous rocks are overlain by Permo-Triassic deposits which form a belt running parallel to the Pennines (Edwards and Trotter 1954: 4). A narrow belt of Magnesian limestone, rarely more than five miles wide, forms a low escarpment running north-south which separates the coal measures to the west from the Permian and Triassic sandstones and mudstones to the east, which form the low-lying Vales of Mowbray and York to the north and the Trent valley to the south. The Trent river system, incorporating drainages from the Southern Pennines and the Derbyshire Peak, has created a broad valley over twenty miles wide bordered in the east by Liassic clays, and the prominent ridge, running north-south, of Jurassic limestone known as the Lincolnshire Cliff (Wilson 1948: 6). This ridge consists of a steep west-facing escarpment rising up to 200 ft. (61 m) above sea-level, and a more gentle dip-slope to the east.

Beyond the Lincolnshire Cliff, lying immediately to the east, is the Lincoln Clay Vale, a low-lying region of Upper Jurassic clays through which runs the River Ancholme, flowing northwards into the Humber, and the River Whitham which flows southward through the Fens of South Lincolnshire into the Wash. At the eastern edge of the Clay Vale the ground rises sharply onto the Lincolnshire Wolds, a broad belt of Cretaceous chalk which runs north-south and continues, as the East Yorkshire Wolds, to the north of the Humber. As noted by Wilson (1948),

> 'The Wolds form part of the scarped chalk uplands which extend almost continuously from the south of England to Flamborough Head.'
>
> (9).

In Lincolnshire the Wolds rise to a maximum altitude of 550 ft. (168 m) above sea-level, whereas in East Yorkshire they are somewhat higher reaching a maximum altitude of 808 ft. (246 m) above sea-level. Topographically, the Wolds landscape has been dissected by streams and springs to create 'an apparent alternation of ridges and valleys' (Wilson op. cit.: 9), without the formation of deeply incised valleys of the kind noted for the Pennines. Further to the east, between the Wolds upland and the present coastline, the Cretaceous chalk is overlain by extensive deposits of boulder clays and silts forming a continuous band of low, irregular relief at about 10 to 30 ft. (3 to 9 m) above sea-level running along the Lincolnshire and East Yorkshire coast as far north as Flamborough Head.

At Flamborough Head the East Yorkshire Wolds meet the coastline to form an upland barrier to the coastal boulder clay deposits. To the north of the East Yorkshire Wolds lies the Vale of Pickering, a broad alluvial plain which runs east-west and is bordered by the upland Cretaceous chalk in the south and the Corallian formations of the North Yorkshire Moors rising to the north. In terms of present drainage patterns in the Vale of Pickering the River Derwent and its tributaries from the North Yorkshire Moors flow westwards through a belt of irregular ridges known as the Howardian Hills to finally join the River Ouse.

The North Yorkshire Moors, which form the northern boundary to the study area, are topographically similar to the Pennines in as much that it is a region of deeply dissected upland much of which exceeds 1000 ft. (305 m) above sea-level, although none of the summits exceeds 1500 ft. (457 m) (Wilson 1948: 10). Geologically, this region of dissected uplands is primarily formed from Middle Jurassic sandstones and shales with some Liassic clays and ironstones.

The considerable variability in relief, geology and patterns of drainage noted for the study area not only meet the physical prerequisites outlined at the end of the previous chapter but also carry significance for the distribution and characterization of lithic raw materials and their sources. Of course, one of the inherent problems of defining a study area is that imposed boundaries are not always sensitive to the relationships between the defined region and areas beyond the defined region. This is true for the archaeological record, and equally true for the availability of lithic raw materials in the study area.

2) The regional lithic resource background

In considering the range of mechanically suitable lithic resources available within the study area three distinct source-types must be accounted for. First, there are sources of materials offering the necessary conchoidal fracture properties that occur with the material still in the parent rock formations within which such materials are formed. Secondly, there are sources where materials from the first category have been removed from their 'parent contexts' and subjected to transportation and subsequent deposition within the study area. Thirdly, there are sources which consist of materials transported into the study area by processes similar to those involved in the second category whose 'parent contexts' lie beyond the study area.

Dealing with each of these in turn, the first category clearly carries the best opportunities for the localization and characterization of raw material sources. Within the study area it is possible to define three distinct parent geological formations containing suitable raw materials.

a) <u>The Cretaceous chalk</u>

The Cretaceous chalk of the Lincolnshire and East Yorkshire Wolds, as discussed previously, represents a northerly continuation of formations which can be found as far south as the coast of eastern Devon. The break in continuity formed by the Wash coincides with a lithological boundary which serves to differentiate between the northern and southern chalk areas (Wright and Wright 1942). Within the northern chalk a four-fold stratigraphical division, based upon lithology, has been proposed (Wood and Smith 1978). These four divisions are termed the Flamborough, Burnham, Welton and Ferriby formations. Of these, only the Burnham and Welton series contain significant quantities of flint.

Within the Wolds the flintless Ferriby formation occupies the scarp slope, whilst the rest of the exposed chalk of the Wolds is of the flint bearing Burnham and Welton formations. Within the Burnham and Welton formations of the Wolds natural exposures are rare (Henson 1982) but sufficient is known from natural and man-made exposures to distinguish between the flints found in the two formations (Wood and Smith 1978). In general, the flint of the Burnham formation occurs in tabular and blocky form, whereas in the Welton formation the flint occurs in a nodular, and sometimes 'dumbell-nodular' form.

As discussed in the previous chapter, the flint derived from the Cretaceous chalk of Lincolnshire and East Yorkshire is an opaque, mottled white. Within the Burnham and Welton formations, however, the flint can be considerably variable in terms of cortex and sizes/numbers of inclusions (Henson 1982). Such variability will convey particular problems for lithic reduction since the numbers/sizes of inclusions will affect the mechanical properties of the material, and impose a degree of uncertainty in the reductional qualities of any given flint mass.

Beyond the Wolds limited exposures of flint bearing Burnham and Welton chalk occur at the base of the boulder clays exposed in cliff sections along the East Yorkshire coastline. Beyond these, however, the occurrence of Wolds flint is largely confined to the limited natural exposures in the Wolds and in secondary deposits.

As a final note, it is possible that at Flamborough Head, on the East Yorkshire coast, outcrops of the normally flintless Ferriby formation may be associated with a brown flint (Henson 1982). From this description alone it is clear that such material would be distinguishable from the flint of the Burnham and Welton formations. However, inspection of the cliffs revealed no clear evidence for such material (Henson pers. comm.).

b) <u>The Carboniferous limestone of the Derbyshire Peak</u>

The limestone Massif of Derbyshire forms a dissected upland dome within which complex lithostratigraphical variations have been recognized. The present limestone outcrop represents, primarily, an area of shelf limestone which abuts with basin limestone formations to the north, west, and south (Cox and Bridge 1977: 3; Stevenson and Gaunt 1971). Where shelf and basin formations meet, discontinuous apron-reef limestones were formed. Within the shelf limestone a broad lithostratigraphical sequence has been constructed, consisting of four general formations - Woo Dale, Bee Low, Monsal Dale and Eyam group. These formations are generally referred to as the S2, D1, D2 and P2 respectively.

Of the above formations the Woo Dale (S2 and basal D1) limestone underlies the entire central dome, at considerable depth, and only outcrops within the shelf province in a few areas, most notably in the vicinity of the Peak Forest anticline (Stevenson and Gaunt 1971: 37). This pale limestone is generally regarded as being free of chert formations (Cox and Bridge 1977: 3), the primary material to be considered as a potential raw material for lithic reduction deriving from the Carboniferous Limestone.

The Bee Low (D1) formations, including Chee Tor and Miller's Dale limestone, are lithologically uniform in their massive bedding and in the presence of clay wayboards between the bedded limestone. Another unifying feature of these limestones is the absence of chert from all but one known exposure or bore-hole record, the exception being the bore-hole record from Pin Dale (SK 158823).

> 'An abnormal feature of the section is the presence of nodular chert in some abundance in the lowermost 23 ft. The exceptional presence of chert in these limestones is perhaps due to a local silica concentration near the reef.'
>
> (Stevenson and Gaunt 1971: 25 - 6).

Given the considerable depth and unique nature of the presence of cherts in this instance it seems reasonable to exclude the Bee Low formations from further consideration as a source of potential lithic material for reduction.

Within the Monsal Dale (D2) formations the limestone has been noted to fall into distinct bands stratigraphically differentiated in terms of colour. The lower Monsal Dale Beds are darker, fine grained and 'bituminous' in places whereas the upper Monsal Dale Beds are pale in colour and coarser textured. Both the upper and lower Monsal Dale limestones outcrop over much of the upland Massif. However, the Monsal Dale limestones form a major component of the north-east of the Massif and it is interesting to note that exposures and bore-hole records from this area emphasize the persistent representation of cherts in nodular, lenticular or bedded forms in this region (Cox and Bridge 1977). By way of contrast, the western margin of the limestone Massif, where Monsal Dale limestones outcrop in association with other formations, in the Dove Holes/Buxton region have produced, despite extensive quarrying and numerous bore-holes (Harrison 1981), no reports of chert in any form from a total of 46 sectional sequences.

Within the chert-bearing Monsal Dale limestones the colour of the chert varies according to the colour of the parent material (Stevenson and Gaunt 1971: 16 - 7) lending support to the chert formational theory of Pettijohn (1957: 439 - 40) that cherts are formed post-depositionally and owe their origins to silicification of partly consolidated rock. Within the north-east of the Massif natural exposures formed through riverine erosion in the Wye Valley and in Lathkill Dale enable the darker Monsal Dale formations to be studied, and it is possible in Lathkill Dale (SK 19446587) to locate beds and lenticular pieces of fine grained, opaque, dense-black chert in section. This chert is in marked contrast to the pale grey, mottled cherts which are to be found in the pale Monsal Dale Beds.

The Eyam group (P2) limestones of the northern shelf province are also known to contain cherts of varying colour and texture (Stevenson and Gaunt 1971: 96 - 105) although little can be said at this stage as to their visual appearance. It should also be noted that there may be outcrops of pale chert-bearing limestone along the southern margin of the shelf province (Henson pers. comm.) although, once again, few details are known at present.

c) <u>The Carboniferous limestone of the North Pennines</u>

In the north-west corner of the study area and extending westwards and northwards from this area are extensive deposits of standard limestone combined with complex, sequential interbedding of limestone, mudstones and sandstones - most notably those of the 'Yoredale Beds' of the Askrigg Massif (Edwards and Trotter 1954: 20; Hudson 1924). The complex 'Yoredale' type bedding does not appear to be found south of the Askrigg Massif and emphasizes the distinction between the limestone series in Derbyshire and that found to the north. Underlying the Yoredale series are the Great Scar limestones - consisting of thick-bedded grey limestones locally interspersed with calcareous grits.

Outcrops of Great Scar limestone underlying and, in some cases, united with the lower limestones of the Yoredale series occur in many of the deeply incised valleys such as Ribblesdale, Wharfedale and Wensleydale. The complex Yoredale sequence, confined to the Askrigg Massif and immediate north, has given rise to a distinctive topography of differentially weathered terraced slopes. South of the Askrigg Massif and the Craven Fault belt (Edwards and Trotter 1954: 27) the Great Scar limestone passes into reef-limestones (Hudson and Mitchell 1937), and the Yoredale series is replaced by Bowland shales.

Whilst the limestones of the Yoredale series, and possibly the exposed Great Scar limestone series contain a variety of grey and grey/brown cherts, with some blue and banded varieties also possibly deriving from this region (Henson pers. comm.) relatively little is known of their precise source contexts. Certainly, to the immediate north of the study area the presence of a variety of coloured cherts have been documented (Hey 1956; Wells 1955) from the standard limestone of the Crow series near Richmond. It seems likely that deep valleys such as Nidderdale and Wharfedale would contain exposures of chert-bearing limestone.

Having identified and discussed the three parent geological sources of potential lithic raw materials for reduction it is necessary, before moving on to discuss secondary sources, to note that it is possible for additional parent sources to exist within the study area. Our understanding of chert-bearing deposits is not sufficiently well advanced as to rule out the existence of alternative sources, particularly in the complex geology of the North Yorkshire Moors. Similarly, volcanic materials associated as intrusive features in the Derbyshire and North Pennine limestone may yield conchoidally fracturing materials.

d) <u>Secondary lithic sources</u>

Within the second category of lithic raw material sources we must include those created by the re-working of parent sources by agents of erosion and the subsequent deposition of these materials. Under this second category are included such sources as riverine gravels containing materials whose parent sources are within the study area. Given the patterns of drainage in the study area (fig. 31) it is possible to identify, once again, three likely source areas. The first concerns the erosion and re-deposition of Wolds flints by the tributaries of, in Lincolnshire, the River Ancholme and River Whitham, and, in East Yorkshire, of the River Derwent. It is to be expected that larger flint masses would tend to be deposited closer to the parent source than smaller masses. Consequently we might see such secondary sources as being most productive in the immediate vicinity of the parent source areas.

To the south, the drainages of the River Trent, including the Dove and the Derwent (Derbyshire) may be expected to have resulted in the transportation of cherts from the Derbyshire limestone down into the Trent Valley. Given the considerable distances involved, however, it is not clear how the constant and prolonged rolling of such material would have affected the size and character of pieces reaching the Trent.

In the north the tributaries to the Ouse River from the incised valleys of the northern limestone - Wensleydale, Nidderdale, Wharfedale - may have carried northern Pennine cherts into the low-lying regions of the Vales of Mowbray and York. Once again, similar doubts exist as to the effects of such erosion and deposition upon the material as applied to the Derbyshire cherts.

Also under this category must be considered sources arising from other agencies of erosion and deposition. Matthews (1977) has identified a series of isolated deposits on the chalk of East Yorkshire and Lincolnshire where solution hollows have created a clay-with-flints matrix bringing Burnham and Welton Wolds flints to the surface. Similarly, within the extensive boulder clay deposits along the eastern coastline of Yorkshire and, less certainly, in

Lincolnshire flint characteristic of the Burnham and Welton formations may be found indicating the re-working of the parent geology by glacial agencies. Similar deposits are known to extend to the west of the Lincolnshire Wolds (Bisat 1940; Jukes-Brown 1885; Straw 1969a) forming extensive areas of basement/chalky till (fig. 33) in the Lincolnshire Clay Vale and beyond. Whilst such deposits may extend to the west of the East Yorkshire Wolds little is known of the content of tills in this region.

The final category of lithic sources to be considered are those formed by erosional agencies transporting material into the study area from sources beyond the study area. Two primary agencies require consideration: riverine and glacial. In the south the Trent River and tributaries extend southwards into the Midlands where extensive deposits of Wolstonian tills (Perrin et al. 1978), containing a variety of flints, may have been reworked with material being carried into the Trent Valley. Within the gravels of the Trent it is possible to recognize a variety of translucent and semi-translucent flints. From visual examination of samples in Derby Museum there appears to be a wide variety of heavily rolled, water-worn flint pebbles ranging from less than 1 cm to nearly 4 cm in diameter. Amongst these were a number of blue/grey semi-translucent flints and bown translucent flints, some of which exhibited an unusual sub-cortex yellow staining.

To the north, the River Ouse and tributaries may have carried materials into the study area from more northerly sources including the chert-bearing limestones of the Crow series (Hey 1956; Wells 1955). Once again, it could be expected that such material would exhibit heavy rolling and water-worn features.

The boulder clays of the study area, and those of the East Yorkshire coast in particular, are known to contain a variety of flints whose origins are believed to be in Scandinavia or sources under the North Sea (Bisat 1939; Phemister 1926). Research into the sub-divisions of the boulder clays in Holderness has a long history (Bisat 1939;

Lamplugh 1891; Melmore 1935) but recent research (Catt and Penny 1966; Straw 1969a) has served to establish a simplified sub-division into three categories - the basement (Yorkshire) or chalky (Lincolnshire) till, the Skipsea (Yorkshire) or Marsh (Lincolnshire) till and the Withernsea till. The general distributions of these deposits are shown in fig. 33.

Following a study of variations in the flint content of the boulder clays along the East Yorkshire coast (Henson 1982) there appears to be a considerable variety, both in terms of colour and texture, in the flints represented. These range from grey flints with poor translucency, poor mechanical properties and which retain their chalky cortex, to grey flints with good translucency, white speckling, few inclusions and a sharp cortex. To these may be added a range of red to brown translucent and semi-translucent flints exhibiting variations in inclusion sizes and cortical thickness. These flints can be seen to differ markedly from the opaque flint of the Wolds.

The diversity of raw materials within the study area presents us with an opportunity for examining lithic procurement changes during the Mesolithic. It is apparent that, in terms of lithic types, the major divisions are those corresponding to the Wolds flint, the semi-translucent and translucent flints of the Trent gravels and eastern boulder clays and the Pennine cherts of Derbyshire and the northern Pennine region. It is, however, important to note that sources beyond the study area may have been visited and contributed to assemblages within the study area. Whilst this problem may not give rise to source identification problems for the defined deposits of the Wolds, the presence of flint-bearing boulder clays to the west of the Pennines on the Cheshire and Lancashire Plains introduces real problems in the sourcing of translucent and semi-translucent materials. Similarly, northern Pennine chert sources beyond the study area may have been visited, thereby contributing to the problems of source assessment. In the latter case it may be possible to distinguish between cherts obtained directly from parent contexts and those derived from secondary contexts on the basis of evidence for rolling and attrition through water-borne transportation.

3) Archaeological background

Some aspects of the Mesolithic archaeological record in northern England and of the study area have already been outlined in previous chapters. In terms of chronology and typology the Mesolithic of the area has been shown to fall into a clear distinction between the Earlier and Later Mesolithic. Prior to approximately 6700 b.c. industries of the post-glacial fall within the descriptive term of 'the North-European Maglemosian technocomplex' (Jacobi 1978a). Whilst there are broad typological similarities within these Earlier Mesolithic industries there has been a growing awareness of a possible sub-division relating both to the presence/absence of certain tool types and in more subtle stylistic and dimensional attributes of other tools.

Jacobi (1978a) has outlined these differences and characterized the two varieties of Earlier Mesolithic industries as assemblages of 'Deepcar' and 'Star Carr' types. The former characteristically contain simple obliquely-blunted points, some of which show additional retouch of the leading edge, and points with convex blunting down the whole of one margin (Jacobi op. cit.: 304). In contrast, assemblages of 'Star Carr' type are characterized by relatively broad obliquely-blunted points lacking the additional retouch of the leading edge, as well as a range of broad isosceles triangles and trapezes - some of the latter being 'elongated'. To these differences in microlithic equipment might be added the presence of steeply blunted awls at Star Carr, and their absence from assemblages of 'Deepcar type'.

One further characteristic serving to distinguish between these two assemblage types lies in the raw materials from which they are made. Whereas 'Star Carr-type' assemblages are made from varieties of speckled-grey semi-translucent flint and translucent honey-coloured flint (Jacobi op. cit.: 305) assemblages of 'Deepcar-type' are invariably dominated by white, opaque Wolds flint from East Yorkshire and Lincolnshire.

Distributionally, 'Deepcar-type' and 'Star Carr-type' assemblages occur over similar areas. Wolds flint dominated assemblages are known from the high elevations of the Pennines at sites such as Warcock Hill North, Lominot 2/3, Windy Hill 3, Pike Lowe 1, Mickleden Edge 1 - 5 and Nab Water 3, whilst the site of Warcock Hill South, also located in the Pennine uplands, is of 'Star Carr-type' (Jacobi op. cit. 304 - 5). Similarly, the upland elevations of the North Yorkshire Moors have produced assemblages of 'Deepcar-type' - Money Howe 1 - and of 'Star Carr-type' - Pointed Stone 1 and 2 (Jacobi op. cit. 307 - 322).

A similar pattern has been recognized along the Lincolnshire Edge where 'Deepcar-type' sites are known from Risby Warren 1 and Willoughton A, whilst 'Star Carr-type' assemblages from Manton Warren 1 and 5 have also been recognized (Jacobi op. cit.: 302 - 305). It has been tentatively suggested, however, that to the west of the Pennines assemblages or finds of 'Star Carr-type' may predominate (Jacobi pers. comm.).

Given the large standard-deviations of Earlier Mesolithic carbon dates relevant to these sites the precise chronological relationships of these two industrial traditions must remain open to question. However, in view of the difficulties associated with accurate sourcing of translucent and semi-translucent flints in comparison with Wolds flint, and the presence of a series of well documented assemblages of 'Deepcar-type' within the study area it was decided, at an early stage of research, to concentrate the analysis of Earlier Mesolithic industrial and lithic procurement patterns upon these 'Deepcar-type' assemblages. Furthermore, in view of the significance of the models for Earlier Mesolithic subsistence, settlement and mobility - as discussed in the previous chapter - to perspectives on the Mesolithic as a whole it was decided that the emphasis should be placed upon an examination of the Earlier Mesolithic archaeological record.

With regards to the Later Mesolithic in northern England the transition to industries characterized by small geometric microliths appears to be uncomplicated by intermediate stages, as may be the case with the Horsham industries in parts of southern England, and has been well documented by excavations and carbon dates. Once again, however, there have been suggestions of stylistic variations in microlith assemblages in the region (Switsur and Jacobi 1975) tentatively related to chronological evidence. However, the precise chronological relationships of assemblages dominated by small scalene triangles and those dominated by straight rod-like microliths with blunting down one or both edges remains difficult to determine. The suggestion that these typological distinctions may correspond to raw material variations (Switsur and Jacobi op. cit.: 33) is of potential significance, given the observations made previously concerning design limitation and raw materials.

As noted previously, in common with the rest of England the case study area witnesses pronounced changes in raw material use between the Earlier and Later Mesolithic. Amongst these changes is the increased representation of a variety of cherts in Later Mesolithic assemblages. In view of the variable understanding of chert types and sources in the study area it was decided to concentrate upon one of the more distinctive types - Black Derbyshire chert - whose source may be broadly defined within the limestone Massif of Derbyshire. It should be emphasized, however, that similar materials may yet be identified from sources elsewhere in the study area.

Within the study area the archaeological record contains considerable locational bias in terms of site distributions and the quantity and quality of excavated assemblages. The considerably improved chances of site recognition provided by the erosion of upland peat deposits in the Pennines and North Yorkshire Moors has long attracted the attentions of amateur and professional archaeologists alike. It is not so surprising, therefore, that the density of known Mesolithic sites is very high in these regions (Jacobi et al. 1976), although within the upland elevations genuine concentrations apparently related to behavioural patterns are discernable (Jacobi 1978a: 325).

In more low-lying regions the quantity and quality of Mesolithic site evidence is considerably reduced, with the notable exception of the sites in the Vale of Pickering which include Star Carr (Clark 1954). Further exceptions to this overall pattern can be found on the Isle of Axeholme and the Lincolnshire Edge where the sheet erosion of sands and soils exposes the buried archaeology and consequently increases the rates of site recognition (Robinson 1968; Straw 1969b). The erosion of cover sands can be directly related to the discovery of Earlier Mesolithic sites on the Lincolnshire Edge such as Risby Warren 1, Willoughton A (Armstrong 1932), Bagmoor (Dudley 1949), Sheffield's Hill (Armstrong 1931) and Manton Warren. It is unfortunate, however, that the quality of documentation and excavation for many of these sites is poor.

4) <u>Analysis of Earlier Mesolithic assemblages</u>

Having decided to concentrate upon an analysis of the 'Deepcar-type' assemblages in the study area a number of important decisions had to be made. Whilst the sorting and counting of lithic assemblages into raw material types to provide the basis for examining percentage variations in raw material representation can be undertaken relatively rapidly, the envisaged detailed analysis of the various waste/by-product categories was clearly going to demand considerable investments of time.

Consequently, a large number of assemblages were examined in order to provide the data on raw material representation. For the more detailed analysis of debitage, however, a limited number of assemblages had to be selected for inclusion. In making this selection a number of points had to be considered. First, if the analysis was to provide useful data on variations in lithic economization related to distances from raw material source the sites selected had to provide variable distances from the source area. Secondly, the debitage analysis would only prove informative if the assemblages included the full range of lithic debris and were not the product of selective tool-orientated collection. Thirdly, if the analysis was to maximize the opportunity for studying lithic reduction strategies within the sort of model outlined in the previous chapter there was a need to sample sites on a systematic basis in order to maximize the chances of observing variations relating to differential site-functions. In the end, sites were chosen for detailed analysis on the basis of the cluster analysis discussed in the previous chapter. Eventually, six sites were selected for inclusion in the detailed analysis of debitage - Deepcar, Warcock Hill North, Lominot 2/3, Unstone 1, Misterton Carr and Nab Water 3. These sites were selected in order to provide the best possible coverage of the various groupings identified by the cluster analysis, thereby providing the basis for examining variability in the lithic reduction evidence related to differential site-function. It can be seen (fig. 23) that the sites of

Deepcar, Warcock Hill North and Lominot 2/3 belong to cluster 1 (see previous chapter), Unstone 1 to cluster 2, Misterton Carr to cluster 4, and Nab Water 3 to cluster 6. It was originally hoped to also provide a detailed examination of the site at Brigham (Manby 1966) but time limitations prevented this. Clusters 3, 5 and 7 contained sites outside of the study area manufactured from materials other than Wolds flint.

a) Raw material representation against distance from source

The procedure adopted in providing quantification of the raw material representation within assemblages was, as far as possible, applied consistently throughout. Variations in the method and structure of assemblage storage, however, imposed certain limitations upon the details of processing. The aim was to obtain data from which, based upon simple counts of the numbers of pieces, the percentage representation by number of raw materials could be derived. The identification of raw material types was based upon the degree of visual distinctiveness of individual types and the degree of confidence in the allocation of sources for these types. Thus, the two most distinctive and reliably sourced materials - white Wolds flint and Derbyshire chert - were quantified separately. The translucent and semi-translucent flints, however, could not be confidently sourced and, given the considerable overlap and range of colours/textures noted for flints from the eastern boulder clays and those from the Trent Valley gravels, combined with the possibility of inputs from sources to the west of the Pennines, it was decided to combine these for quantification. Notes were made on the variations in cortex for the translucent/semi-translucent flints including any occurrence of sub-cortical yellow staining as noted for flint from the Trent Valley gravels.

Although the sources of other Pennine cherts are, at present, poorly understood it was felt that the prospects for improved definition exist. Consequently, an attempt was made to provide categories based upon colour, although these may prove to be rather general. Two categories were created, blue/grey chert and grey-banded chert, and applied in quantifying raw materials. Raw materials which did not fit into the above categories were counted separately and notes made concerning colour and texture.

Of the fourteen assemblages examined and quantified for raw material content (table 9; fig. 34) it can be seen that, in general, they fall into three locational groups. Two of the sites, Risby Warren 1 and Willoughton A (Armstrong 1932), are located on the northern Lincolnshire Edge. Brigham (Manby 1966), on the other hand, is a site located on the crest of a small hill, approximately 50 ft. (15 m) O.D., made of alternating bands of sand and gravels overlooking the surrounding flat-lands of Holderness. Interestingly, Manby (1966) noted that,

> 'The Brigham sands and gravels rest on brown boulder clay that is not exposed...but its upper limits are marked by a series of small springs around the base of the hill.'
>
> (211).

The remaining sites are located within or close to the Pennine uplands. Within this latter group, however, marked locational variations may be noted. The site of Unstone 1, recently excavated by the North Derbyshire Archaeological Trust (Courtney and Pierpoint n.d.; Hart 1981: 30), is located on a small spur at approximately 440 ft. (134 m) O.D. overlooking the confluence of the River Drone and the Barlow and Sud brooks. This area lies within the broad coal measures zone which forms a belt running north-south along the eastern margin of the Pennines and the Carboniferous limestone Massif of the Derbyshire Peak.

The site of Deepcar (Radley and Mellars 1964) is located at approximately 500 ft. (168 m) O.D. on a small spur overlooking the confluence of the Don and Porter rivers. This spur projects out into a valley surrounded by the Pennine uplands. To the south are the high escarpments of Wharncliffe Crags, whilst to the north and west the valleys deepen and lead up to the moors of the Southern Pennines (Radley and Mellars op. cit.: 1). As such the site is located in an intermediate position between the Pennine uplands and the low-lying regions to the east including the Sheffield basin.

The remaining sites fall into two general groups located within the uplands of the Southern and Central Pennines. The Southern Pennine sites of Pike Lowe 1, and the four sites of Mickleden Edge 1 - 4 (Radley and Marshall 1965) all lie on the gritstone upland block isolated by the Little Don River to the north and Ewden Beck to the south between 1300 and 1500 ft. (396 and 457 m) O.D.. The Central Pennine group includes the sites excavated by Francis Buckley (1924; Petch 1924) of Lominot 2/3, Windy Hill 3, and Warcock Hill North, and a site excavated by John Gilks, Nab Water 3, presently unpublished. Lominot 2/3, situated at 1400 ft. (427 m) O.D., Windy Hill 3 situated at 1250 ft. (381 m) O.D., and Warcock Hill North situated at 1250 ft. (381 m) O.D. all command extensive views being located along the edge of the central watershed, or just to the south and east of the Central Pennine summits of the region (Radley and Mellars 1964: 13 - 18). The site of Nab Water 3 occupies a narrow spur of land at approximately 1250 ft. (381 m) O.D. commanding views of the eastwards drainages of the Oxenhope region of the Central Pennines (Gilks pers. comm.). This Central Pennine group forms part of a concentration of Mesolithic evidence from the higher elevations of the uplands in an area where the Pennine watershed is at its narrowest.

In seeking to calculate the relationship between Wolds flint representation and distance from source it was necessary to provide an estimate of distance. A number of points arose in providing such an estimate. First, many of the sites, most notably those belonging to the Central Pennine group, can only be located to a general area, fixed by six-figure grid references. Secondly, although the Wolds flint is distinctive it is not possible to isolate any particular point as the place of procurement. The Wolds provide a continuous potential source-area, or 'supply-zone' (*sensu* Burton 1980: 141), running north-south, allied to

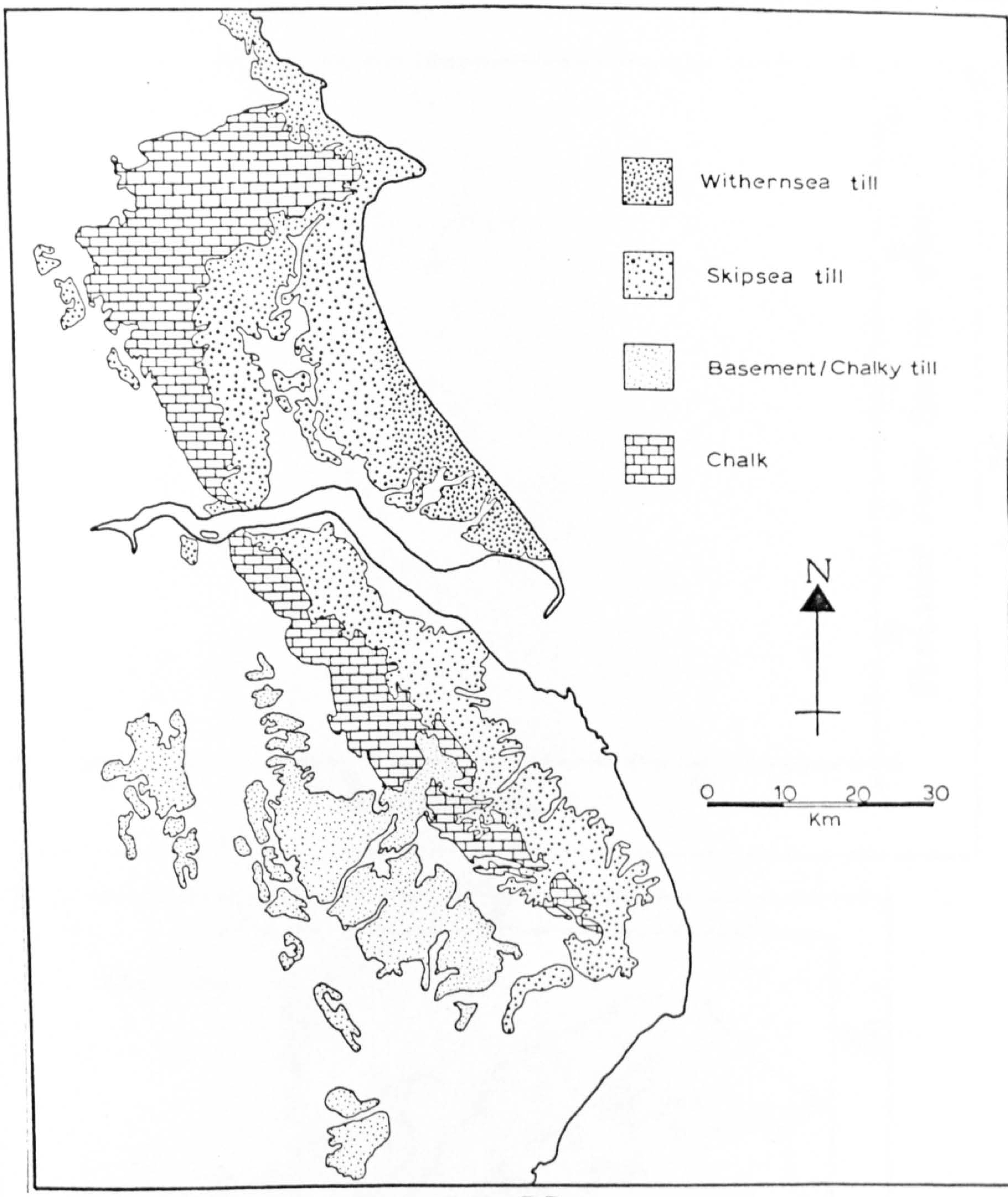


fig. 33

table. 9

RAW MATERIAL PERCENTAGES FOR 'DEEPCAR TYPE' EARLIER MESOLITHIC ASSEMBLAGES							
SITE	KMS FROM WOLDS	WHITE FLINT %	BLUE/GREY CHERT %	BLACK CHERT %	BANDED CHERT %	TRANSLUCENT FLINT %	VOLCANIC %
BRIGHAM	8	92.49	-	-	-	7.51	-
DEEPCAR	72	95.93	-	3.47	-	0.60	-
LOMINOT 2/3	91	90.98	2.46	-	1.78	4.78	-
MICKLEDEN 1	81	83.05	-	14.41	-	2.54	-
MICKLEDEN 2	81	97.00	-	2.00	-	1.00	-
MICKLEDEN 3	81	99.92	-	-	-	0.08	-
MICKLEDEN 4	81	99.46	-	-	-	0.54	-
NAB WATER 3	81	87.50	-	0.51	1.07	8.18	0.68
PIKE LOWE 1	80	99.18	-	-	-	0.82	-
RISBY WARREN 1	9	89.60	-	-	-	10.40	-
UNSTONE 1	75	86.41	0.13	4.72	-	7.94	-
WARCOCK HILL NORTH	89	96.00	1.70	0.09	0.01	2.20	-
WILLOUGHTON A	16	80.80	-	-	-	19.20	-
WINDY HILL 3	93	95.91	0.13	0.25	-	3.71	-

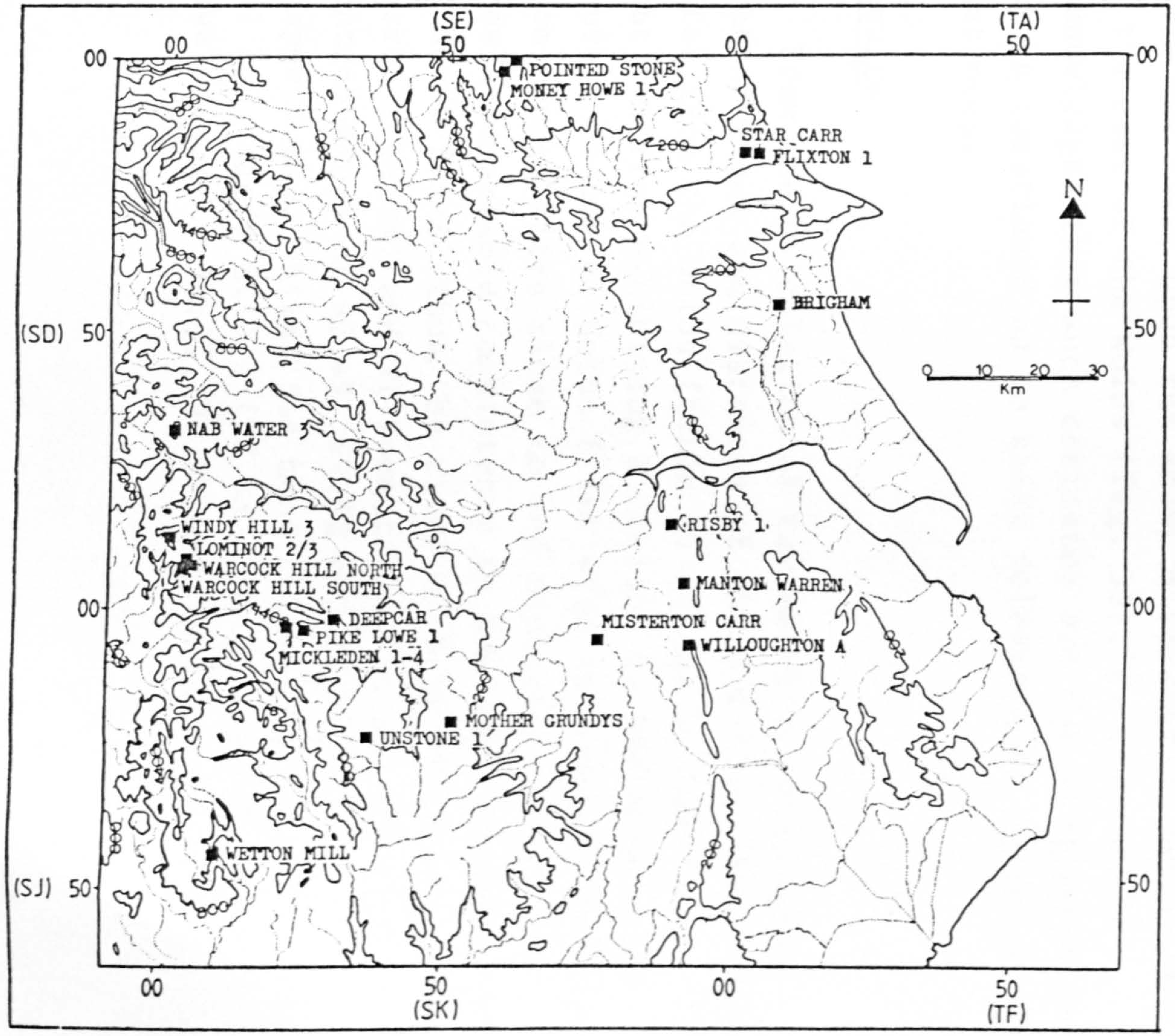

(SE)
(TA)
00
50
POINTED STONE
MONEY HOWE 1
STAR CARR
FLIXTON 1
N
BRIGHAM
0 10 20 30
Km
(SD) 50
NAB WATER 3
WINDY HILL 3
LOMINOT 2/3
WARCOCK HILL NORTH
WARCOCK HILL SOUTH
DEEPCAR
PIKE LOWE 1
MICKLEDEN 1-4
RISBY 1
MANTON WARREN
MISTERTON CARR
WILLOUGHTON A
MOTHER GRUNDYS
UNSTONE 1
WETTON MILL
(SJ) 50
(SK)
(TF)

fig. 34

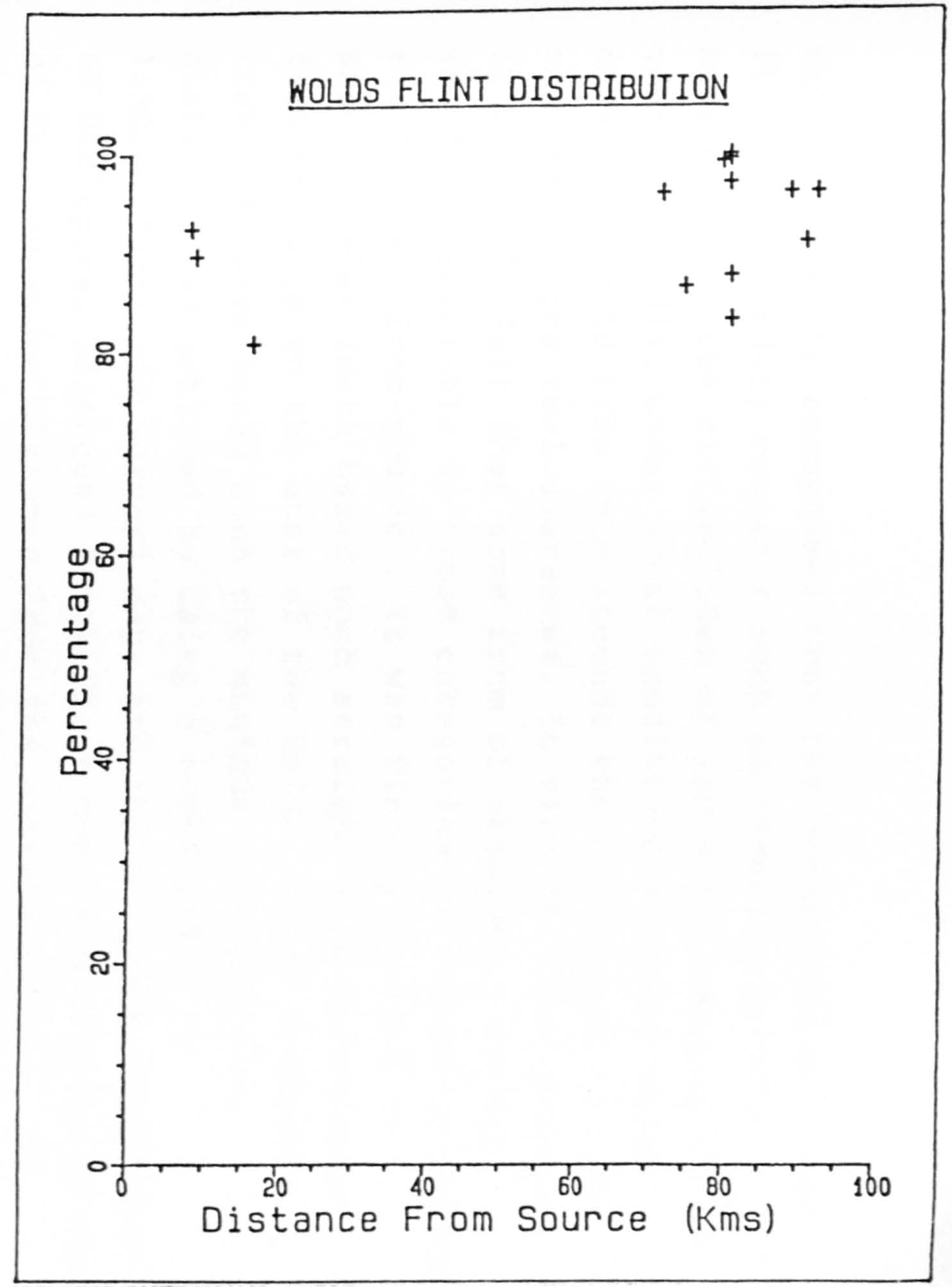

WOLDS FLINT DISTRIBUTION
Percentage
0
20
40
60
80
100
Distance From Source (Kms)

fig. 35

which it must be recognized that the occurrence of Wolds flint in secondary contexts such as riverine gravels must compound the difficulties of isolating one particular source. Thirdly, under ideal conditions distance-decay modelling would take into account the effects of variable topography upon real distances. In view of these problems it was still felt that some form of absolute estimate would be preferable to broad categories of 'close-to-source' and 'distant-from-source'. It was finally decided to provide an estimate based upon straight-line measurement from the site to the edge of the Wolds. These estimates (table 9) were based upon the minimum straight-line distance (km) achieved by using a combination of 1:50000 (Ordnance Survey) maps and the 1:625000 (Institute of Geological Sciences) South-Sheet map, with the exception of Brigham whose distance from the eastern edge of the Wolds was based upon the known distribution of boulder clays to the east of the Wolds (fig. 33). It is readily acknowledged that such estimates are far from ideal and may be questioned as to their relevance to on-the-ground distances.

Results

From the calculation of raw material percentage contributions and distances of these Earlier Mesolithic sites from the Wolds (table 9) it can be seen (fig. 35) that far from exhibiting a decline in the percentage representation of Wolds flint with increasing distance from source sites close to and distant from the Wolds show a remarkable consistency in the high representation of Wolds flint. Thus, the sites of Brigham (8 km), Risby Warren 1 (9 km) and Willoughton A (16 km) have percentage contributions of 92.4%, 89.6% and 80.8% Wolds flint respectively, whilst the most distant sites of Lominot 2/3 (91 km), Windy Hill 3 (92 km) and Warcock Hill North (89 km) have values of 90.9%, 96.0% and 96.0% respectively. Indeed, based upon these fourteen sites the percentage contribution of Wolds flint would appear to exhibit a marginal increase with increasing distance from source (r = 0.4058: fig. 35).

As noted in the previous chapter, on the occasions when attention has been focussed upon the remarkably high proportions of Wolds flint in Pennine assemblages the significance attached to this pattern has varied between vague suggestions of 'contacts' between the Pennines and the eastern lowlands (Radley and Mellars 1964: 8) to the more specific suggestions of Jacobi (1978a: 304) that groups were incorporating the Pennines and eastern lowlands within seasonally based procurement strategies. Certainly, in view of the normal expectations for distance-decay effects in association with indirect procurement mechanisms (see chapter 2), the absence of such an incremental decay with increasing distance would appear to militate against the procurement of Wolds flint through exchange or barter mechanisms by groups in the Pennines.

From the discussion of direct procurement mechanisms in chapter 2, however, it would also appear that if the procurement mechanism for Pennine assemblages had been through direct task-group organization for the collection of Wolds flint then we might expect a linear fall-off with increased distance. Such a situation would presumably entail task-groups moving up to 190 km in round-trips solely for the purpose of maintaining raw material supplies. Whilst such a situation is not beyond the bounds of possibility it seems unusual that more local, high-quality sources of Derbyshire black chert only contribute a small percentage to the Pennine assemblages (table 9). The absence of a fall-off with increased distance would appear, therefore, to indicate that procurement was organized through some alternative direct mechanism.

The model of embedded procurement, introduced in chapter 2 and developed in chapter 4, would appear to provide us with a viable basis for considering procurement mechanisms which generate distributions without distance-cost effects or decays. Under the 'pure' embedded model developed by

Binford (1979) the occurrence of spare transporting capacity during the course of subsistence related task-group mobility is assumed as constant throughout the year. The input of embedded raw material supplies, therefore, is evenly structured and produces assemblages whose raw material content reflects, directly, the scale of subsistence task-group mobility. The absence of any cost-distance constraint associated with raw material supplies could be expected to be reflected in the absence of any decay effects with increased distance from source.

Given the agreement between the expectations of the pure embedded model and the Wolds flint data we might conclude that the Pennine assemblages reflect a system where supplies of raw material were maintained through task-groups moving from the Pennines to the Wolds in response to subsistence procurement tasks and returning with regular embedded inputs of Wolds flint. Whilst such a situation is not impossible this would imply that our current understanding of Earlier Mesolithic subsistence scheduling is totally inadequate. Under present thinking it is hard to understand why groups resident in the Pennines would seek to heavily exploit the low-lying regions of the Wolds through task-groups moving out from residence sites.

Under the developed model of embedded procurement, however, the occurrence of spare transport capacity during the course of subsistence related task-group mobility is seen as being differentially distributed throughout the annual subsistence cycle. Within the model of Earlier Mesolithic subsistence, scheduling and mobility outlined in chapter 4 significant variations in the scale and regularity of embedded inputs of raw materials were envisaged. These variations were argued to be structured around changes in the strategies of food procurement characterized as specialist autumnal intercept hunting and generalist encounter hunting strategies of spring and summer. Given this subsistence model the focus of activities during spring and summer would be the lowlands whilst during autumn the emphasis would shift to the uplands and, in particular, the river valleys leading up onto the upland summits.

In terms of embedded procurement the most regular and predominant inputs could be anticipated from areas exploited through generalist, encounter strategies partly as a reflection of the greater uncertainty of game procurement in comparison with the highly intensive, efficiency stressed intercept strategies of autumn. From this we might see the predominance of Wolds flint in Pennine assemblages, combined with the relatively minor contributions from Pennine raw material sources (table 9), as indicating the sort of subsistence activity differentiation envisaged in the revised model of Early Mesolithic subsistence outlined in the previous chapter as an alternative to the Clark model (1972). By implication, the Pennines, and other upland regions, will have provided the locational focus for subsistence activities during the autumn, whilst much of the remaining annual cycle was spent engaged in generalized strategies appropriate to the lowland regions.

Such a model would accommodate the absence of a distance-decay effect in the distribution of Wolds flint as the raw materials will have been obtained through embedded inputs during spring and summer, but would raise certain questions concerning details of the organization of technology. In particular, if lithic procurement through embedded strategies provided the bulk of lithic raw materials during spring and summer how was the technology organized so as to provide adequate supplies - at no constraint - for the autumnal strategies in upland regions? In other words, how was the supply of Wolds flint to Pennine regions organized in such a way as to avoid conflicts in the time allocated to technological and subsistence activities? Given the efficiency stressed nature of the postulated autumnal intercept strategies it is clear that there will have been selective pressures operating favouring technological accommodations designed to prevent potential conflicts in time allocation. From this it follows that supplies of lithic materials for technology during the autumn must have been anticipatorily organized using the embedded inputs from spring and summer. Unlike the pure embedded model, therefore, we might expect to see evidence for the anticipatory collection and preparation of lithic materials for the autumnal period on sites occupied during spring and summer. Such a response would introduce elements of differential patterning in debitage between occupation sites of the spring/summer and autumn periods.

The evidence for the percentage representation of Wolds flint in Earlier Mesolithic assemblages would appear, therefore, to suggest that the mechanism of procurement did not incur costs relative to the distance from source. In view of the expected cost-distance relationships incurred through indirect and direct task-group organized procurement mechanisms it would appear that models of embedded procurement mechanisms provide us with the most appropriate possible explanations for the observed pattern. Clearly, both the pure embedded model and the developed embedded model, as applied to the case study, imply that the subsistence-related mobility of Earlier Mesolithic groups incorporated extensive areas within annual movement. At the most general level the scale of subsistence mobility proposed by Clark (1972) and widely accepted (Jacobi 1978a; Mellars 1976a) for Earlier Mesolithic populations would appear justified in the light of the evidence.

In terms of the relative roles and scale of residential and logistical mobility, however, the pure and embedded models convey significantly different implications. Under the former we would have to envisage the regularized use of logistical mobility from Pennine residential sites with a heavy emphasis upon food procurement in the low-lying regions to the east of the Pennines incorporating the Wolds of East Yorkshire and/or Lincolnshire. Whilst logistical round-trips of 200 km are not, of themselves, outside of the realms of possibility neither the Clark (1972) model nor the revised (chapter 4) model of Earlier Mesolithic subsistence/settlement would account for such behaviour.

The developed embedded procurement model would, however, provide a viable mechanism for explaining the observed patterning within the revised model of Earlier Mesolithic subsistence and settlement. Given the stress placed in chapter 2 upon the desirability of employing a variety of analytical approaches towards examining lithic economization and the considerable implications of rejecting the Clark (1972) model in favour of the revised model of Earlier Mesolithic subsistence and settlement it was felt necessary to provide additional tests for cost-distance effects upon lithic assemblages whilst also seeking to provide the basis for evaluating some of the organizational implications identified as part of the revised model. Consequently, in examining the six assemblages selected for detailed analysis the procedures developed for data collection were designed to provide the data for evaluating these two separate issues.

b) Wolds flint debitage analysis

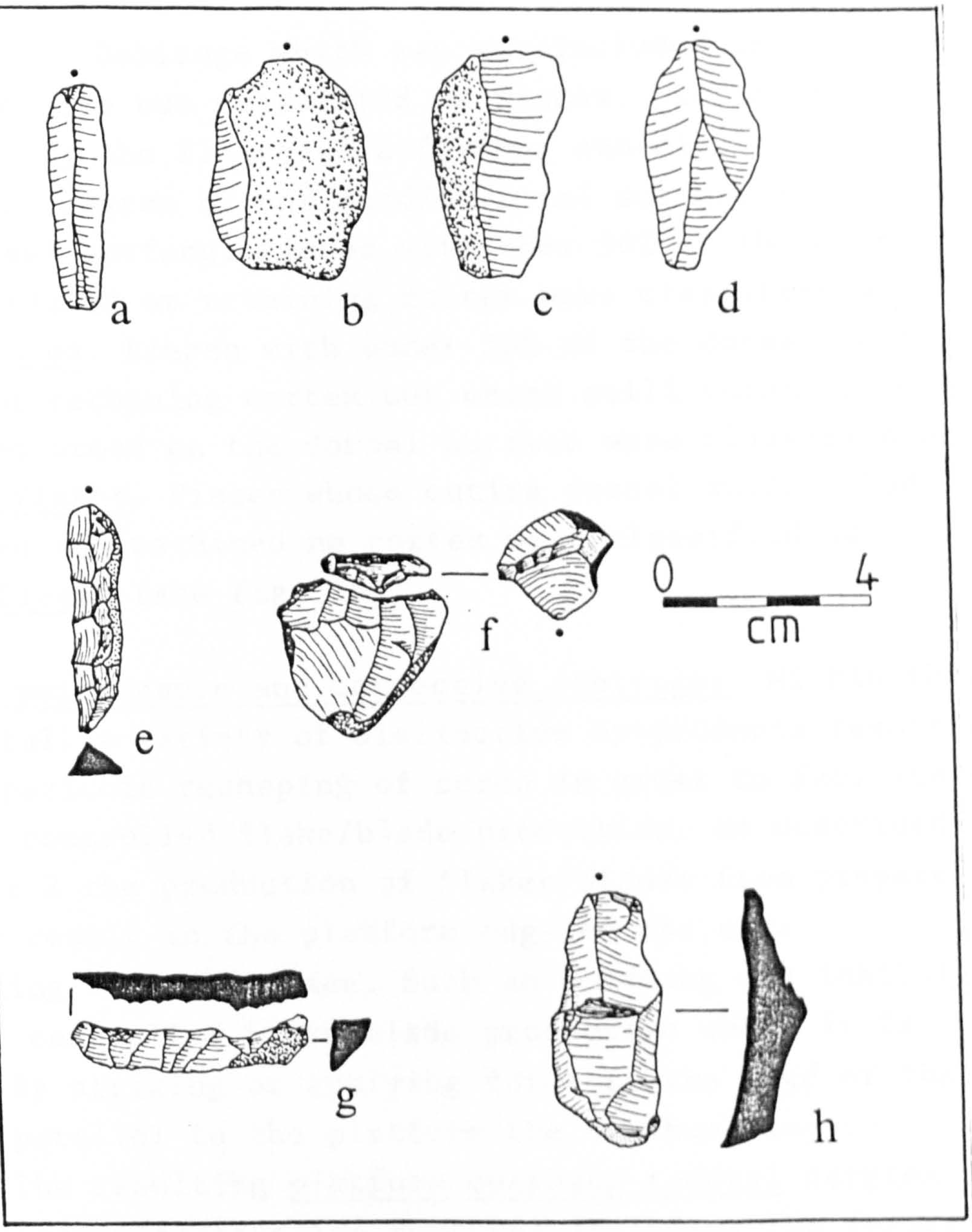
The analysis of debitage focussed upon the Wolds flint component of the six assemblages selected for study. By concentrating upon this distinctive raw material not only was it intended to examine the effects of variable distance from source upon lithic economization but also to examine the inter-assemblage organization of lithic reduction. The potential significance of the differing mechanical properties of raw materials upon reduction strategies (Henson 1982; Knudson 1973; Straus 1980) argued for the comparison of site reduction data to be based upon a single raw material type. In the light of the subsequent analysis it became evident that the reduction of Wolds flint, translucent and semi-translucent flint, and varieties of chert did exhibit marked differences stemming from variability in the raw material form.

Sorting procedure

In as much as the conditions of assemblage storage would allow the sorting procedure applied to the six assemblages was held constant. Having separated an assemblage into the various raw material types the Wolds flint component was subjected to further sorting. All pieces exhibiting retouch were separated from the unretouched material and treated separately. The unretouched material was sorted and classified into a series of debitage categories. These categories were designed to provide information upon the reductive sequence as outlined in the discussion of stage analysis (see chapter 2). The categories employed were as follows:

i) Blades: Whilst the term 'blade' has a long-established position in the discussion of lithic debitage the physical attributes serving to define blades from flakes remain subject to debate (Pitts 1978a). Whilst for certain descriptive purposes it may prove adequate to employ simple morphological criteria, such as length/breadth ratios, as the basis for illustrating the degree of 'bladedness' for assemblages it was felt that such approaches could not be productively employed here. Arbitrarily constructed definitions of length/breadth ratios, it was felt, may prove insensitive to the conceptual position of blade production within stage analysis as a distinct technological stage. One of the characteristics of Mesolithic assemblages is the high frequency of broken/snapped segments of blades - pieces exhibiting parallel margins with one or more ridges running down the length of the piece at right angles to the platform - which would effectively eliminate a large proportion of the blade population from the blade category if such arbitrary length/breadth ratios were employed.

Whilst it is readily acknowledged that the more subjective criteria employed here - parallel margins and ridges with no cortex - may be questioned it was felt that in view of the fact that the classification was to be undertaken by one person for the specific purposes of this analysis there would be a high level of internal consistency for the comparison of the assemblages included in the analysis (see fig. 36).



a, blade: b, primary flake: c, secondary flake: d, tertiary flake (a-d, Deepcar): e, ridge flake (Warcock Hill North): f, refitted core and core platform rejuvination flake (Rocher Moss 1): g, core platform edge rejuvination flake (Rocher Moss 1): h, core face recovery flake (Warcock Hill North).

fig. 36

ii) Flakes: Debitage which was not included in the other categories was classified as flakes. Within this broad category the flakes were further sub-divided on the basis of the degree of unflaked/cortical surface remaining on the dorsal surface. Pieces with over 50% of the dorsal surface unflaked or retaining cortex were classified as primary flakes. Pieces with under 50% of the dorsal surface unflaked or retaining cortex but which still retained cortex or unflaked areas on the dorsal surface were classified as secondary flakes. Pieces whose entire dorsal surface had been flaked and retained no cortex were classified as tertiary flakes (see fig. 36).

iii) Core maintenance and corrective debitage: Within this category fall a variety of distinctive by-products resulting from the periodic reshaping of cores in order to facilitate continued controlled flake/blade production. As described in chapter 2 the production of flakes/blades from prepared cores may result in the platform edge of the core 'overhanging' the core face. Such an overhang may inhibit continued controlled flake/blade production until it is removed. By striking or applying force to the edge of the platform parallel to the platform the overhang may be removed. The resulting platform overhang removal carries with it certain distinctive features including the former edge of the platform surface and the scars of previous flake/blade removals just below the platform edge. Generally, these pieces are triangular in section (fig. 36).

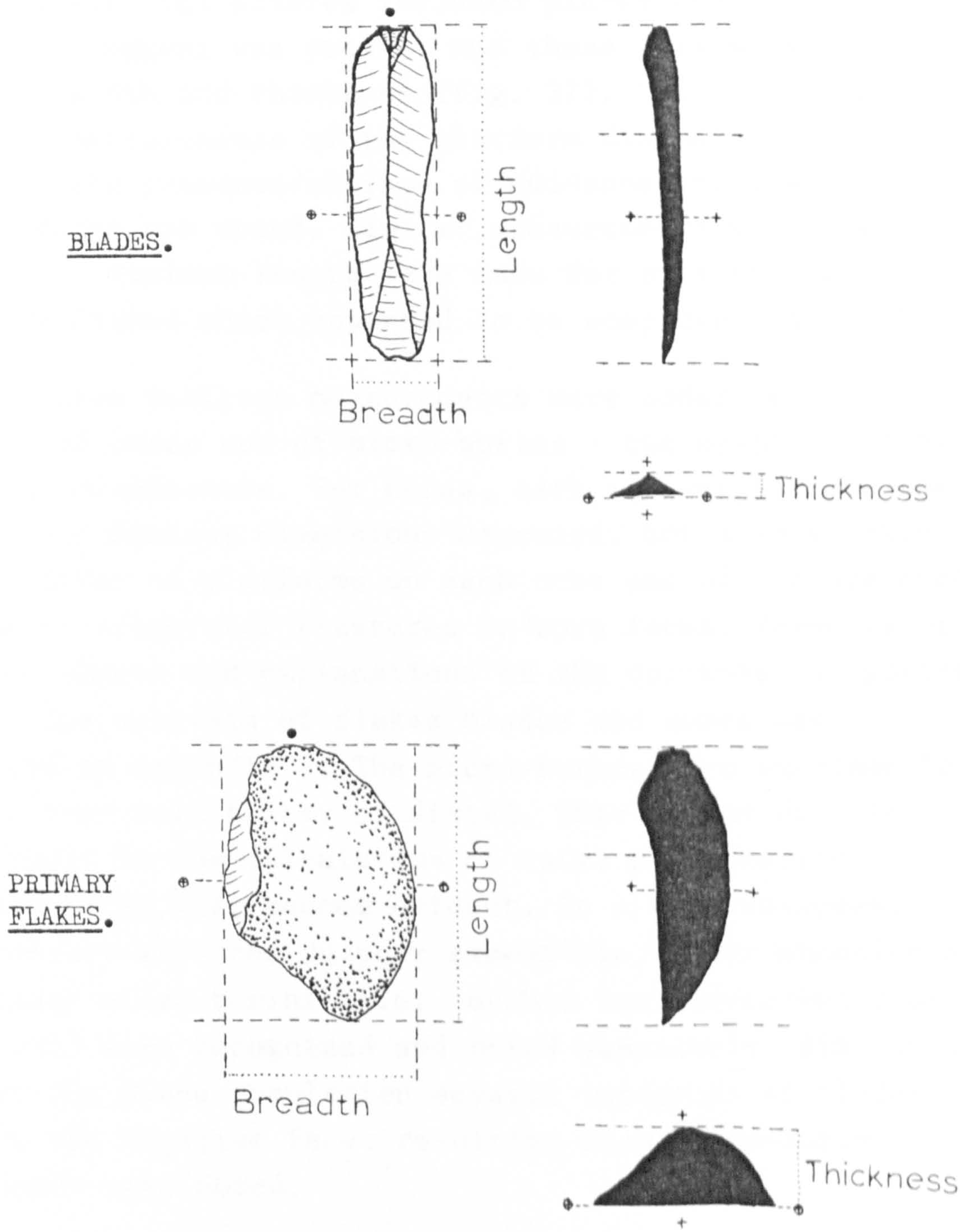
Similarly, the reduction of a prepared core through flake/blade production may periodically result in the loss of a suitable angle between the core platform and face. In order to restore a suitable angle for continued controlled flake/blade removals the old platform may be 'cleaned-off' by striking or applying force parallel to the core platform. The resulting core platform removal may be produced in a variety of forms with the force being applied to the core face, lateral to the core face, or from the rear of the platform. In all cases, however, the resulting removal carries distinctive features including the former core platform, the scars of former blade/flake removals on the former core face and the evidence for the applied force of removal. Generally, such pieces are flattened in shape forming the characteristic 'core-tablet' shape with former blade/flake scars around part of the edge of the piece (fig. 36). Similar removals may have served to clean-off awkward scars on the edge of the platform surface in order to facilitate continued core use. On occasion the creation of a new platform through the removal of a plunging-blade (see chapter 2) may have extended core use. although few examples of this technique were recognized in the assemblages.

A third, and more controversial sub-category relates to the removal of unwanted features on a core face, such as hinge and step fractures or isolated inclusions within the core. These core face recoveries may be recognized through the presence, on the dorsal surface, of the unwanted features taken off the core face. Generally, these pieces are relatively thick reflecting the application of force deep onto the core platform in the attempt to recover the core face (fig. 36). Once again, pieces included in this sub-category were confined to clear examples. Flakes with small step fractures clustered around the platform edge were excluded and only those pieces with one or more large or obvious hinges/steps/or inclusions were included.

A final sub-category noted was the ridge/keeled flake, being the product of initiating a fresh series of ridges on the core face for subsequent flake/blade removal. Ridge flakes may be recognized from the presence of a series of lateral alternating flake scars forming a central ridge down the dorsal face of the flake (fig. 36). However, relatively few clear examples were identified in the analysis.

Quantification and measurement

Having sorted the debitage into the above categories the flakes and blades were further sorted and counted into those pieces retaining the proximal end features (platform, bulb of force) and those without (mid-sections and distal



MORPHOLOGICAL ATTRIBUTE MEASUREMENT: Length, Breadth and non-bulbar Thickness.

fig. 37

ends). Having counted and weighed the various sorted units these were sub-sampled using a prepared numbered grid and random number tables (Lindley and Miller 1953). The samples were then subjected to detailed measurement. For the blades the samples included pieces where the non-bulbar segment was present and these were measured for maximum breadth and thickness (fig. 37). For the blade proximals measurements of the platform dimensions were taken and the presence/absence of evidence for platform strengthening was noted. Similar measurements with the addition of maximum length were made for primary and secondary flakes which appeared to be complete (fig. 37).

To these debitage measurements were added detailed analyses of cores and of micro-burins - the by-products of microlith manufacture. For cores, each was weighed and the maximum and minimum dimensions measured. Notes were taken on the number of platforms on each core and of the presence/absence of hinge/step fractures on core faces. Examples of the data sheets and explanations of the variable categories used in the analysis of flakes/blades and cores are presented in appendix 3. The micro-burins were examined for whether they were bulbar or distal. This latter data is significant in the calculation of rates of microlith manufacture as will become evident. In a few instances, most notably with the Deepcar assemblage, clear examples of incomplete micro-burins (i.e. notched but undetached from the blade) were recognized and noted separately. Similarly, amongst the blade population several instances of blades bearing the negative facet resulting from micro-burin detachment were noted.

<u>Debitage data for the six assemblages: recovery bias</u>

i) <u>Misterton Carr</u>

The site of Misterton Carr (Buckland and Dolby 1973) was recognized following deep ploughing which brought large numbers of flints to the surface. Repeated and intensive surface collection supplemented by trial excavations in

1971 produced a large assemblage from three neighbouring concentrations. The Wolds flint component included typically Earlier Mesolithic tool forms such as tranchet-axes and some 54 obliquely-blunted microliths. The presence of later Prehistoric material in the form of Late Neolithic/ Early Bronze Age arrowheads, knives and portions of polished stone-axes indicated the presence of mixed-period deposits. However, these later Prehistoric lithics were consistently manufactured from varieties of translucent/semi-translucent flint quite distinctive from the Earlier Mesolithic Wolds flint industry. Due to this mixture of periods the assemblage was excluded from the analysis of raw material percentages (table 9).

ii) <u>Unstone 1</u>

The site of Unstone 1 (Courtney and Pierpoint n.d.) was excavated during 1977 and 1978 following the recognition of the site during field survey. Excavation was based upon the results of controlled recording of the surface scatter after ploughing had disturbed areas of the site, and a total area of 161 m^2 was finally excavated. Traces of structural features were recognized with some indication of repeated occupation - at least two phases - being recognized. From the typological analysis of the lithic tools it appeared that both phases of occupation were Earlier Mesolithic in date. A total of 4066 artefacts were recovered with the majority of the site being sieved using a c. 3 mm mesh size. Following a comprehensive analysis of the lithics undertaken by Dr. S. Pierpoint the material was stored in Sheffield City Museum. Each lithic piece was allocated a number using sticky labels, and whilst such a procedure may have aided the initial analysis problems were encountered during the re-analysis undertaken here. I am, however, grateful to Dr. Pierpoint for providing me with access to the computer file on which his analysis was stored. Using this file enabled the use of the original weight measurements for each piece in the course of re-analysing the material. In undertaking the present analysis the assemblage was studied and treated in total, although under ideal circumstances it would have been preferable to examine the two phases separately.

iii) Warcock Hill North

The site was discovered and excavated by Francis Buckley during 1923 and 1924 (Buckley 1924: 5 - 7; Petch 1924: 27; Radley and Mellars 1964: 13 - 18). The excavations covered an area of c. 250 sq. yds. and revealed a large assemblage of over 5000 pieces occurring principally in four distinct circular patches with each being roughly 4 yds. in diameter. The assemblage, dominated by Wolds flint, contained a range of typical Earlier Mesolithic tool forms including obliquely-blunted points identical to those found at Deepcar, Misterton Carr and other Earlier sites in the region. One point of interest was the discovery of a brown translucent flint scraper, similar to those found at the 'Star Carr-type' (*sensu* Jacobi 1978a) site of Warcock Hill South (Buckley 1924: 3 - 5; Radley and Mellars 1964: 15), lying some 2 inches below the Wolds flint level on the edge of the Warcock Hill North site (Buckley 1924: 5).

iv) Lominot 2/3

Located to the north-west of Warcock Hill North this site was also excavated by Francis Buckley and was originally identified as two sites although excavation subsequently revealed 'two round emplacements' (Petch 1924: 25) forming one site. Once again, the presence of typical Earlier Mesolithic tool forms, similar to the other sites under consideration, made principally from Wolds flint underlines the typological consistency of the 'Deepcar-type' (*sensu* Jacobi 1978a) assemblages. Thanks to the diligence of the excavator samples of carbon from the site, excavated in the twenties, were preserved in glass boxes in the Tolson Memorial Museum in Huddersfield and radiocarbon dated to 7610 ±350 b.c. (Q - 1187) (Switsur and Jacobi 1975).

Whilst it is always possible to cast doubts upon the quality of the excavations undertaken by Buckley the assemblages from his work appear to confirm that unlike so many early excavators Buckley attempted to recover all of the lithic debitage as well as the tools. Furthermore, thanks to his personal interest in micro-burins (Petch 1924: 87 - 92) we can assume that recovery rates for this particular debitage category were relatively good. Once again, although the radiocarbon evidence which has resulted from the careful storage of carbon by Buckley (Switsur and Jacobi 1975) may have high standard-deviations and be subject to criticism (Bonsall pers. comm.) it is remarkable how consistent they have proven in the light of more recent samples and dates (see chapter 3).

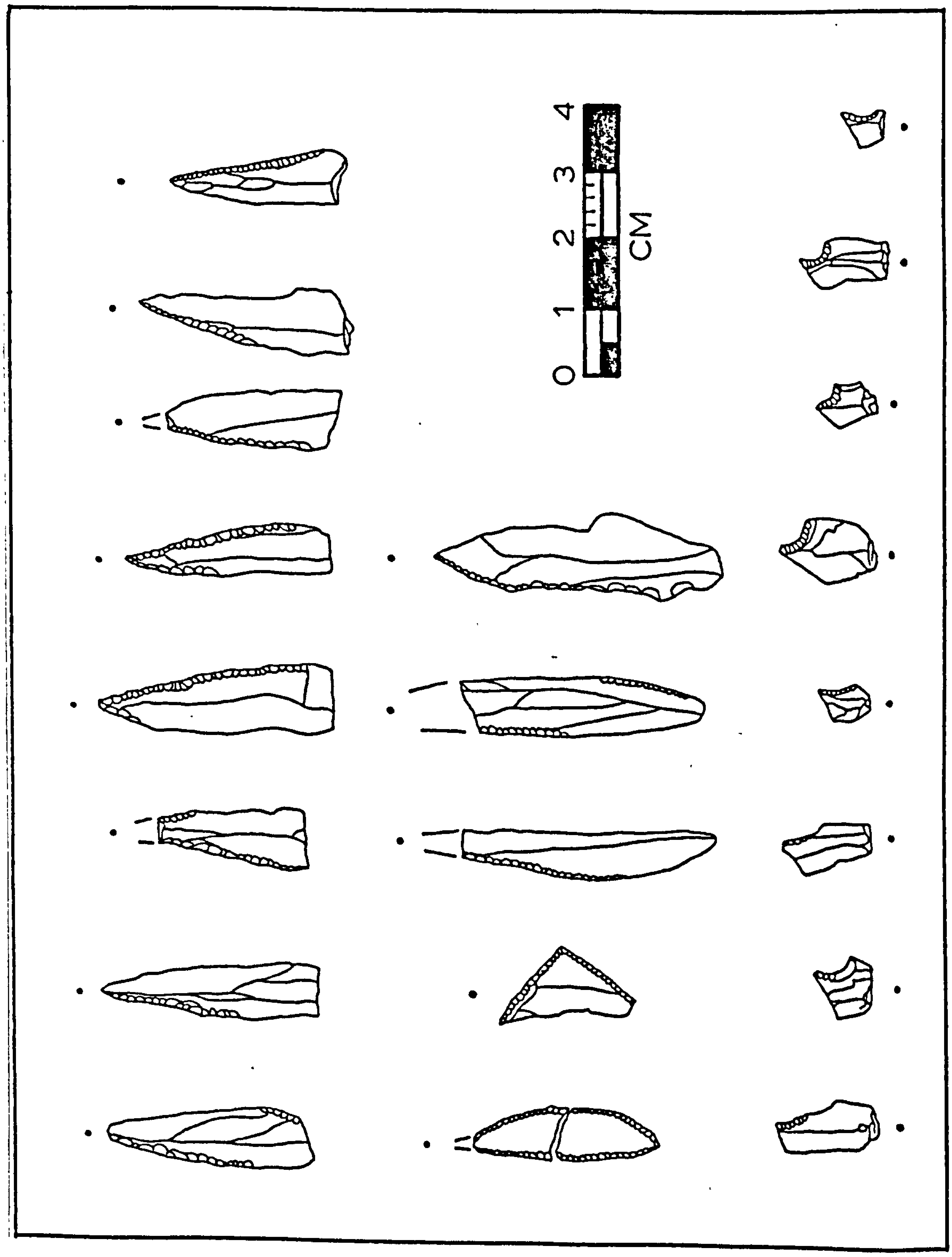
v) Nab Water 3

The assemblage from Nab Water 3 was recovered by J. Gilks of the Tolson Memorial Museum following initial work by the Bradford Antiquarian Society (Gilks pers. comm.). As yet unpublished this assemblage was collected and excavated from a very heavy matrix within a well defined area. As with the other assemblages under consideration the material is predominantly Wolds flint, with a remarkable series of obliquely-blunted points and one isosceles triangle (fig. 38).

vi) Deepcar

The site of Deepcar (Radley and Mellars 1964) was excavated during 1962 following surface collection and an initial trial excavation undertaken by Mr. F. Hepworth. The site, prior to excavation, had been partially destroyed by quarrying along its western margin. Excavations yielded a very large assemblage of c. 23000 pieces manufactured principally from Wolds flint. In addition to the typically Earlier Mesolithic industry the site yielded one of the most substantial structures known from Mesolithic contexts in Britain (fig. 39). The structural evidence consisted of an outer ring of, in the north, quartzite blocks and, in the south, local flags of sandstone. Within this structure, interpreted as a possible windbreak footing (Radley and

fig.38



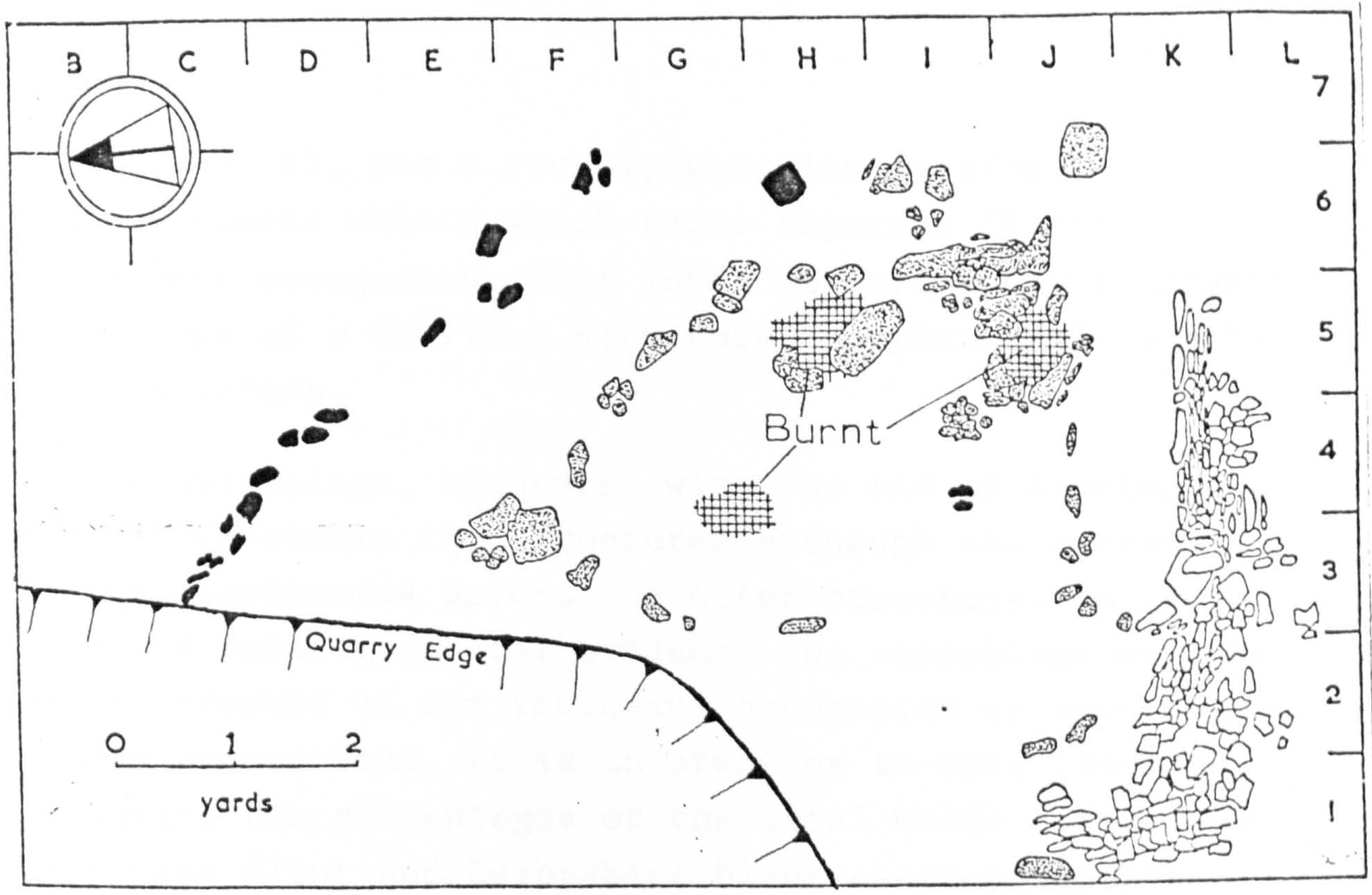

Burnt
Quarry Edge
0 1 2
yards

fig.39

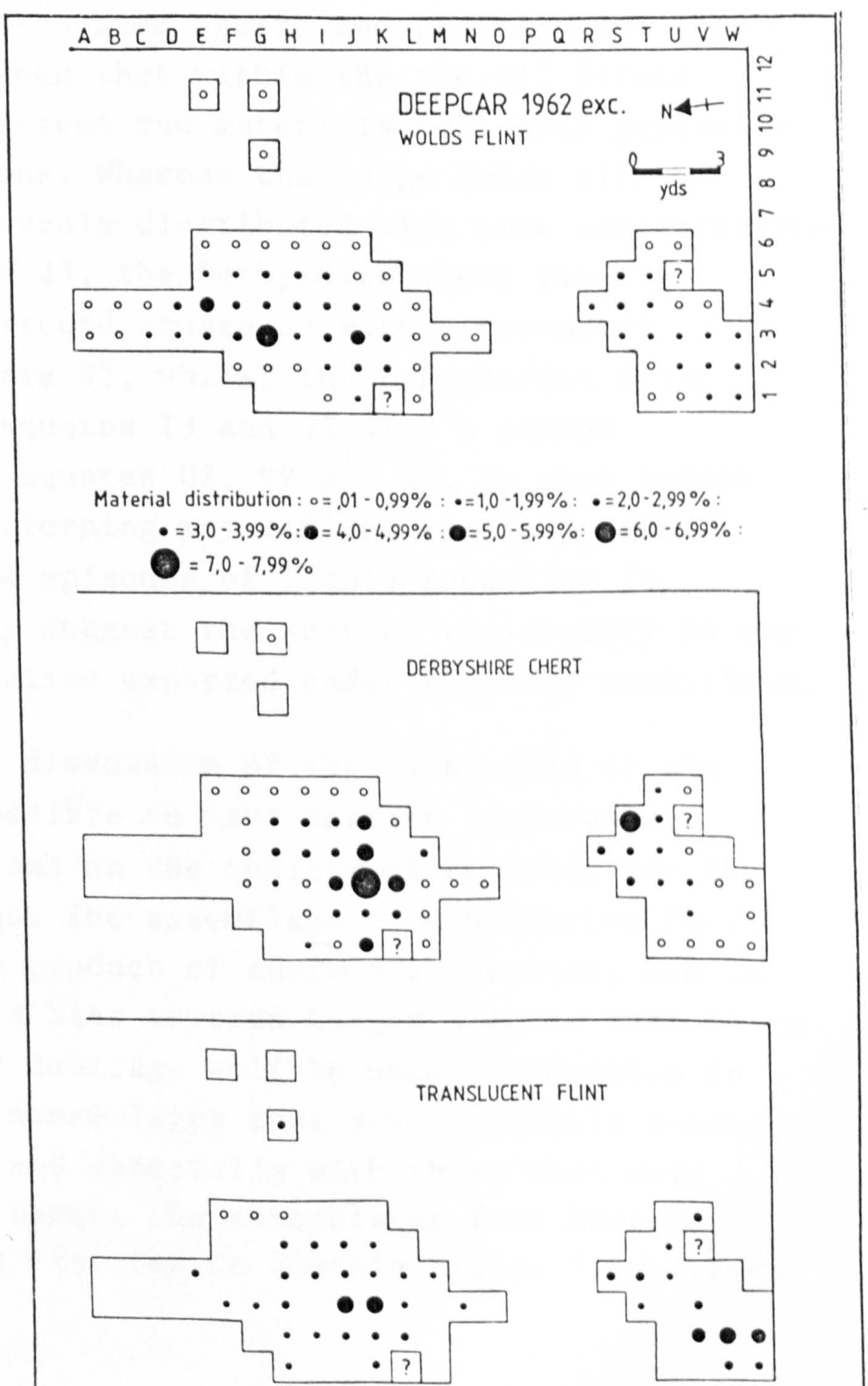

DEEPCAR 1962 exc.
WOLDS FLINT
N
yds
Material distribution: ○ = ,01 - 0,99% : • = 1,0 - 1,99% : • = 2,0 - 2,99% : • = 3,0 - 3,99% : ● = 4,0 - 4,99% : ● = 5,0 - 5,99% : ● = 6,0 - 6,99% : ● = 7,0 - 7,99%
DERBYSHIRE CHERT
TRANSLUCENT FLINT

fig.40

Mellars 1964: 6), was a roughly circular setting of gritstone blocks within which three separate 'burnt' patches were recognized. This inner structure may represent the footings of a dwelling structure, approximately 4.5 by 3.5 yards across.

The assemblage, recovered with the aid of sieving, was concentrated within the structures although the spread continued southwards beyond the outer structure. In the absence of stratigraphical evidence the assemblage may have been the product of one intensive occupation or several repeated occupations. It is interesting to note that by calculating the percentages of the total Wolds flint, translucent flint and Derbyshire black chert components separately for each excavated square and plotting the results (fig. 40) it can be seen that within the overall lithic distribution the different raw materials fall into generally distinct concentrations. Whereas the large Wolds flint assemblage is quite evenly distributed with some concentration in squares G3, E4 and J3, the Derbyshire chert clearly concentrates in and around square J3 with a secondary concentration in square S5, whilst the translucent flint concentrates around squares I3 and J3 with a second concentration around squares U2, V2 and W2. To what extent this differential patterning may reflect spatially (and temporally?) discrete episodes of lithic reduction is uncertain, but it may suggest the sort of variability in the locus of lithic reduction expected under repeated conditions.

From this brief discussion of the background to the assemblages it is possible to make certain important cautionary observations on the quality of recovery for the different collections. The assemblage from Misterton Carr, in being largely the product of surface collection, can be expected to exhibit a bias towards larger pieces. That is to say that the smaller debitage will be underrepresented in comparison with the assemblages that were primarily recovered through excavation, and especially with those that were sieved. By the same token, the assemblages from Unstone 1 and Deepcar might be expected to contain higher frequencies of smaller debitage than other excavated but not sieved assemblages.

The anticipated variability in recovery rates for the assemblages introduces certain problems and limitations in the comparison of debitage. Where recovery is biased in favour of larger pieces we can expect, for example, tertiary flakes to be underrepresented relative to primary and secondary flakes. Similarly, under the same conditions we might expect the dimensions of blades to be biased towards larger pieces. In view of such considerations it is clear that simple comparisons of debitage data between the sites could prove highly misleading unless treated with extreme caution. Once again, in seeking to assess the evidence for or against increasing lithic economization with increased distance from source for the six assemblages care needs to be taken in the selection of indices of economization which may be held as independent of bias in size-range recovery rates.

Data presentation

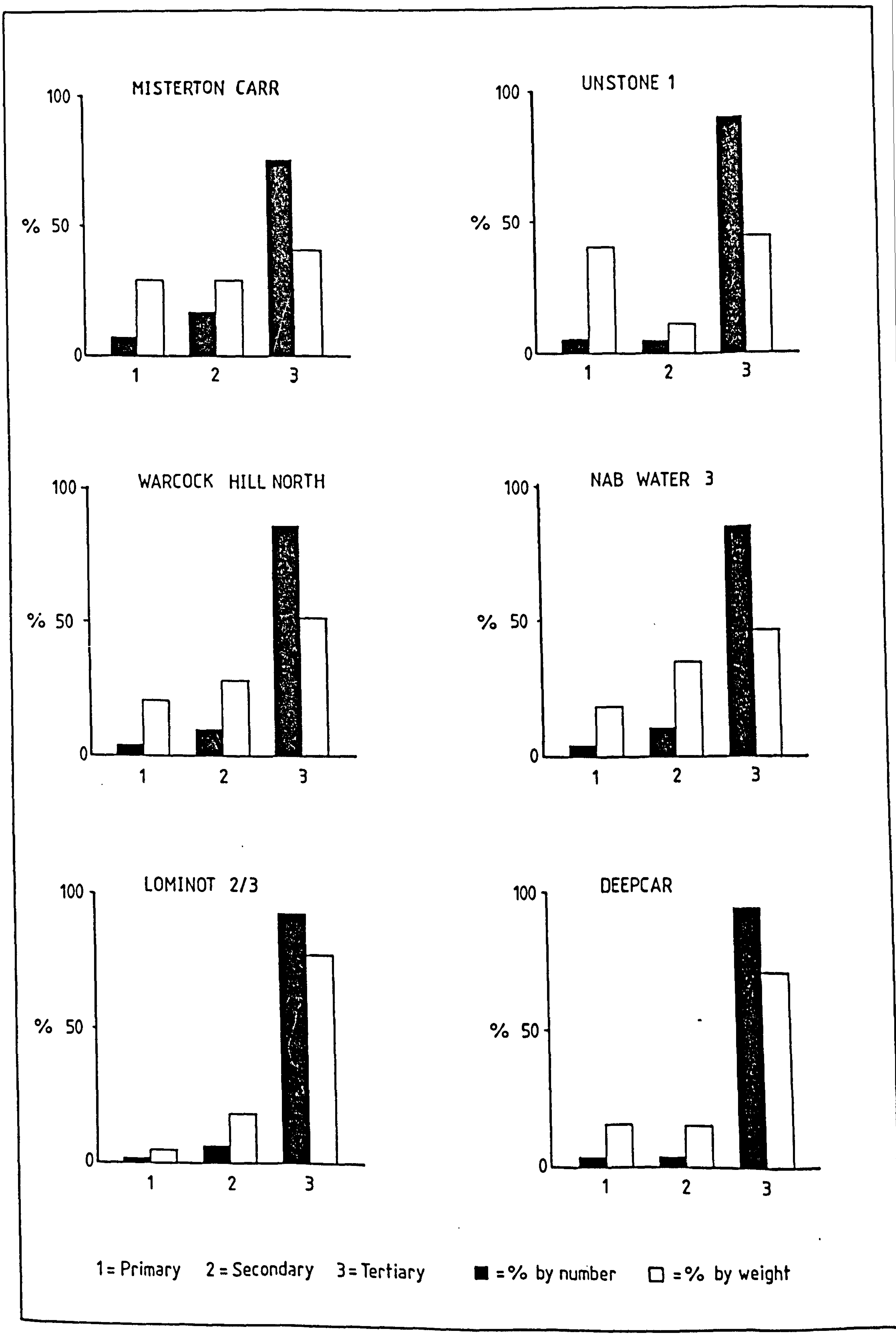
i) Flakes

The data on the percentage representation by number and weight for primary, secondary and tertiary flakes for the assemblages (table 10; fig. 41) reveals certain significant variations between the sites. In terms of the percentages of tertiary flakes Misterton Carr has a lower representation by number than any of the other sites. Accordingly, the total percentage of primary and secondary flakes, by number, is higher (24.96%) at Misterton Carr than at Unstone 1 (9.15%), Warcock Hill North (14.2%, Nab Water 3 (15.17%), Lominot 2/3 (7.73% or Deepcar (6.43%).

From these figures it can also be seen that (fig. 41) the range in the percentage by number of tertiary flakes exhibits considerable variability with Deepcar (93.57%) having the highest value, with Unstone 1 (90.94%) and Lominot 2/3 (92.27%) also having high values whilst Warcock Hill North (85.79%) and Nab Water 3 (84.83%) have slightly lower values. Misterton Carr, as indicated, has a markedly lower value of 75.04%.

Site		PROXIMAL			MID-SECTION/ DISTAL			TOTALS			TOTAL PERCENTAGES	
		No.	Wt.	$\bar{x}$.Wt	No.	Wt.	$\bar{x}$.Wt	No.	Wt.	$\bar{x}$.Wt	%.No	%.Wt
MISTERTON CARR	PRIMARY	72	946.0	13.14	29	539.4	18.60	101	1485.4	14.71	7.73	29.40
	SECONDARY	124	1036.5	8.36	101	448.9	4.44	225	1485.4	6.60	17.23	29.39
	TERTIARY	495	1326.1	2.68	485	755.7	1.56	980	2081.8	2.13	75.04	41.20
UNSTONE 1	PRIMARY	-	-	-	-	-	-	180	482.3	2.68	5.90	43.18
	SECONDARY	-	-	-	-	-	-	99	127.7	1.29	3.25	11.43
	TERTIARY	-	-	-	-	-	-	2769	507.1	0.18	90.94	45.39
WARCOCK HILL NORTH	PRIMARY	83	520.6	6.27	149	281.7	1.89	232	802.3	3.46	4.18	20.77
	SECONDARY	173	632.7	3.66	383	460.5	1.20	556	1093.2	1.97	10.02	28.30
	TERTIARY	1390	931.5	0.67	3369	1036.1	0.31	4759	1967.6	0.41	85.79	50.93
NAB WATER 3	PRIMARY	24	105.1	4.38	27	51.5	1.91	51	156.6	3.07	4.58	18.70
	SECONDARY	54	173.5	3.21	64	118.2	1.85	118	291.7	2.47	10.59	34.83
	TERTIARY	306	196.0	0.64	639	193.3	0.30	945	389.3	0.41	84.83	46.48
LOMINOT 2/3	PRIMARY	23	60.0	2.61	26	24.8	0.95	49	84.8	1.73	1.59	4.71
	SECONDARY	76	145.2	1.91	113	180.7	1.60	189	325.9	1.72	6.14	18.11
	TERTIARY	831	732.0	0.88	2008	657.3	0.33	2839	1389.3	0.49	92.27	77.18
DEEPCAR	PRIMARY	302	786.1	2.60	291	292.7	1.00	593	1078.8	1.82	3.18	15.44
	SECONDARY	228	416.8	1.83	379	603.3	1.59	607	1020.1	1.68	3.25	14.60
	TERTIARY	5780	2832.2	0.49	11682	2057.1	0.18	17462	4889.3	0.28	93.57	69.98

table.10



MISTERTON CARR
UNSTONE 1
WARCOCK HILL NORTH
NAB WATER 3
LOMINOT 2/3
DEEPCAR
100
% 50
0
1
2
3
1 = Primary
2 = Secondary
3 = Tertiary
■ = % by number
□ = % by weight

fig. 41

In very broad terms the percentage by weight values agree with the above figures. One notable deviation from this correspondence, however, can be seen (table 10; fig. 41) in the Unstone 1 data where the percentage by weight value for tertiary flakes (45.39%) is markedly lower than the percentage by number value (90.94%) might have initially led us to expect. The calculation of the mean weights for primary, secondary and tertiary flakes for the assemblages (table 10) reveals, however, further differences between the assemblages. Most striking are the consistently higher mean weight values for primary, secondary and tertiary flakes at Misterton Carr. For example, primary flake mean weight at Misterton is 14.7 g whilst the next highest value from the other five assemblages is 3.46 g at Warcock Hill North. Similarly, the mean weight for tertiary flakes at Misterton Carr is 2.1 g whilst the next highest value is 0.49 g at Lominot 2/3. The smallest value for tertiary flakes is 0.18 g at Unstone 1.

To what extent can we attribute these differences in the proportions of primary, secondary and tertiary flakes, and in their mean weights to the expected bias in recovery rates? Given that we would expect poor recovery to produce a reduced representation in smaller material, and given that tertiary flakes consistently form the smallest/lightest of the three categories it is not surprising that the lower percentage of tertiary flakes at Misterton Carr comes from an assemblage produced primarily through surface collection. By the same token, it is not surprising that the sieved assemblage at Unstone 1 produced one of the higher percentage by number values for tertiary flakes, and the smallest mean weight value for the same category. In other words, we can clearly detect the effects of differential recovery rates upon the data.

We must now ask to what extent do these biases account for all of the variability? The data derived from the measurement of random samples of complete primary flakes provides us with an informative insight into this question (table 11; fig. 42). The data for primary flake lengths

	n	x̄.L	sd	v	cv
MISTERTON CARR	30	51.70	18.385	326.743	0.356
UNSTONE 1	30	31.47	13.746	182.648	0.437
WARCOCK HILL NTH.	30	41.13	15.242	224.582	0.371
NAB WATER 3	17	41.76	11.824	131.592	0.283
LOMINOT 2/3	14	31.17	10.447	101.353	0.335
DEEPCAR	30	32.70	15.563	234.143	0.476
RANDOM SAMPLES OF COMPLETE WOLDS FLINT PRIMARY FLAKES					

table 11

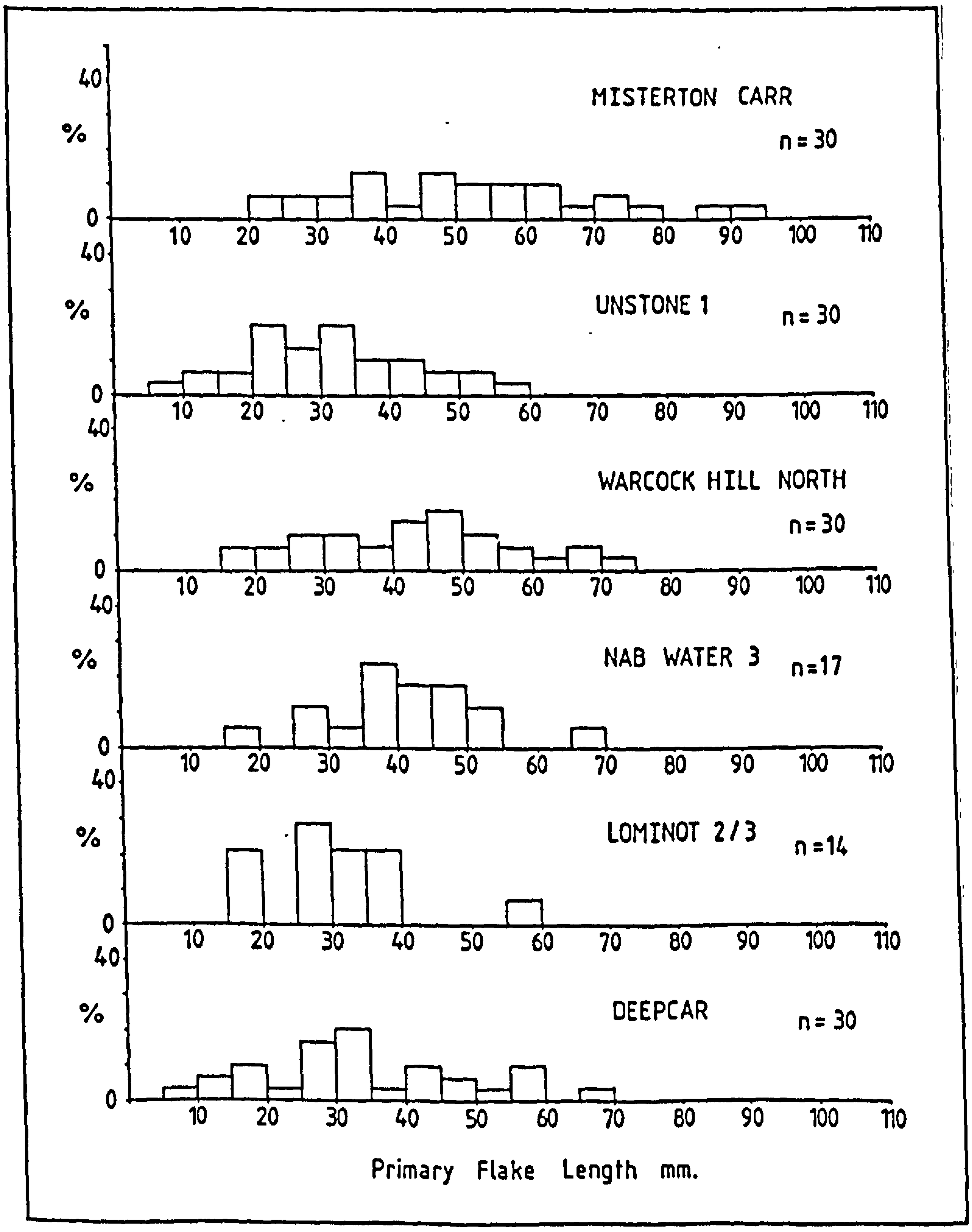


fig. 42

(fig. 42) clearly illustrates two aspects of the assemblage characteristics relevant to this problem. On the one hand, the sieved assemblages at Unstone 1 and Deepcar both contain primary flakes whose lengths are smaller ($<$ 15.0 mm) than those recovered at other sites. On the other hand, whilst the assemblage from Misterton Carr would appear to have an underrepresentation of primary flakes less than approximately 35 mm in length there is also a clear representation of primary flakes whose lengths (sizes) are greater than in any of the other assemblages. Even allowing for the very small sample sizes from Nab Water 3 and Lominot 2/3 it can be seen (fig. 42) that the presence of primary flakes whose lengths are greater than 75 mm distinguishes this assemblage from the others. It is worth noting that the impression of larger flake categories at Misterton Carr was apparent at the time of data collection and is not regarded as the result of the random sample ignoring such size classes at the other sites. The higher mean length for primary flakes at Misterton Carr (51.7 mm) in comparison with the other sites (ranging from 41.764 mm to 31.171 mm) would, therefore, appear to, in part,actually reflect the presence of very large primary flakes not represented in other assemblages. By the same consideration, the higher mean primary flake weight at Misterton Carr would appear to reflect the presence of a number of very large pieces in the flake assemblage (fig. 43c). The same observation may apply to the secondary flake mean weight data.

ii) Cores

The study of Wolds flint cores (table 12; fig. 44) provides a further insight into variations in the lithic debitage. Whilst the bias in recovery rates may influence all classes of debitage the size and obvious nature of cores would argue that of the various debitage categories they will be least influenced by such bias. One of the most noticeable differences between the assemblages was the presence at Misterton Carr, and absence from the other assemblages, of a series of very large, virtually unmodified Wolds flint masses and a series of very large masses clearly

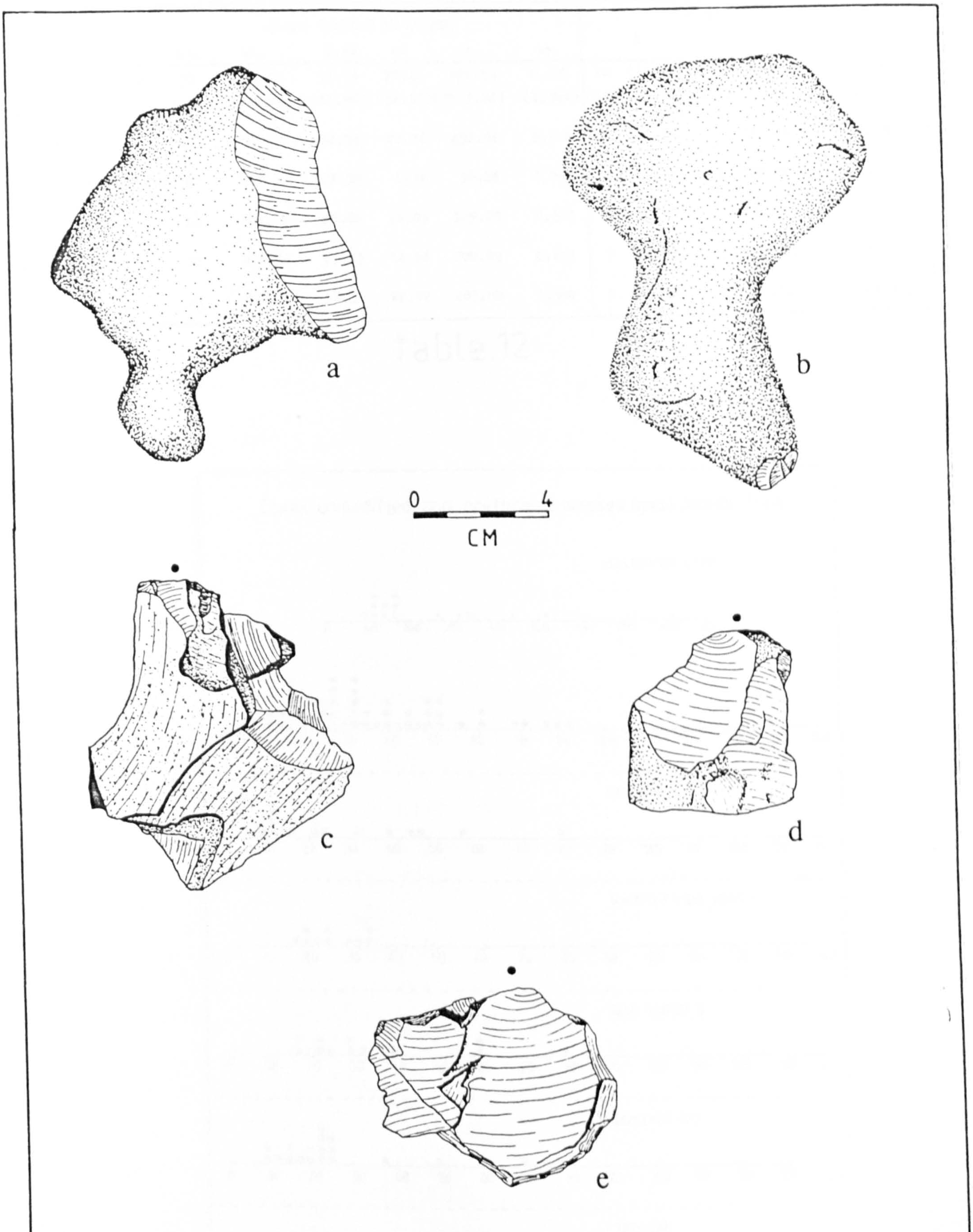


fig. 43

	CORES (WEIGHT IN GRAMS)						No. of Platforms		
	No.	Wt.	$\bar{x}$.Wt	sd	v	cv	1	2	3
MISTERTON CARR	53 (54)	1990.68 (2427.84)	37.56 (44.96)	22.18 (58.63)	482.83 (3373.84)	0.591 (1.304)	14 (26.4%) (15) (27.7%)	37 (69.8%) (37) (68.5%)	2 (3.8%) (2) (3.7%)
UNSTONE 1	11	362.34	32.94	22.26	450.66	0.676	4 (36.4%)	6 (54.6%)	1 (9.0%)
WARCOCK HILL NTH.	10	245.80	24.58	6.34	36.16	0.260	4 (40.0%)	6 (60.0%)	- -
NAB WATER 3	14	504.28	36.02	18.83	329.29	0.523	3 (21.4%)	11 (78.6%)	- -
LOMINOT 2/3	18	421.74	23.43	14.56	200.08	0.621	7 (38.9%)	7 (38.9%)	4 (22.2%)
DEEPCAR	14	550.20	39.30	22.82	483.80	0.580	3 (21.4%)	7 (50.0%)	4 (28.6%)

table.12

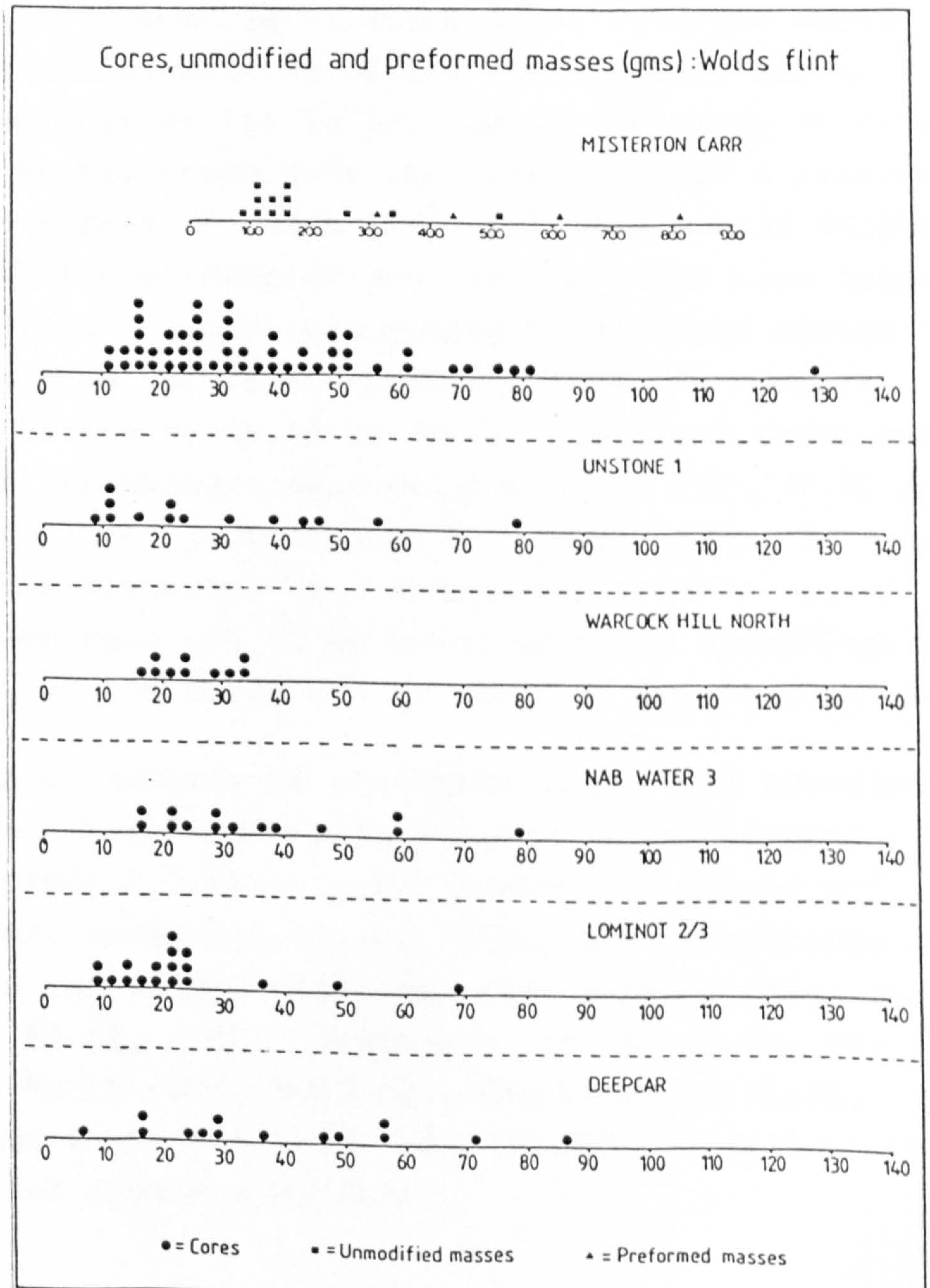


fig. 44

prepared as cores but not showing any signs of flake/blade production (table 13). These Wolds flint masses generally occurred in two forms - nodular (fig. 43a and b) and tabular/blocky - which may reflect procurement from differing contexts. The nodular forms carried a grainy cortex forming an even outer skin on the rounded, 'dumb-bell' shaped mass. The tabular/blocky forms carried a cortex which was smoother and more varied, whilst in shape these masses were quite angular and irregular. In terms of weight these masses can be seen (fig. 44) to be consistently heavier (and larger) than the cores of Wolds flint in the assemblage.

With respect to the cores it can be seen (fig. 44) that for the six assemblages, quite apart from the marked variations in the numbers of cores, there are differences in both the mean sizes (table 12) and in the range of sizes represented. At Misterton Carr the cores exhibit a considerable range in the weights of cores (fig. 44) with a mean weight of 44.96 g, whilst at Deepcar and Unstone 1 the mean weights of 39.3 g and 32.94 g are accompanied by standard deviations (table 12) of 22.8 and 22.26 respectively which compare favourably with the value of 22.18 for Misterton Carr. For the remaining assemblages mean weights range from 36.02 g at Nab Water 3 to 23.43 g at Lominot 2/3. Once again, it would appear that the Misterton Carr assemblage contains cores that are larger than are to be found in other assemblages although some of the cores are as small as any found elsewhere.

In terms of numbers of platforms (table 12) two-platform cores are consistently the most frequently represented excepting Lominot 2/3 where equal numbers of single and double platform cores were found. Thus, the proportions of single, double and triple platform cores found at Misterton Carr (26.4%, 69.8%, 3.8%), Unstone 1 (36.4%, 54.6%, 9%), Warcock Hill North (40%, 60%, 0%), Nab Water 3 (21.4%, 78.6%, 0%) and Deepcar (21.4%, 50%, 28.6%) all reflect the predominance of double platforms.

iii) Blades

Given the bias in recovery rates between the assemblages it was anticipated that the comparison of blade sizes would reflect the varying recovery standards at the six sites. As can be seen (table 13) the data on mean blade weights does, in part, reflect the anticipated pattern. The highest value, 0.81 g, comes from the site with the poorest recovery standard - Misterton Carr - whilst the smallest value, 0.38 g, comes from the sieved site of Unstone 1. From this it was clear that any comparison of blade dimensions based upon any single direct measurement of a blade size attribute would prove highly misleading in discussing levels of economization in blade production. For example, if blade width was employed as an index on the assumption that increased economization would favour narrower blade production (see chapter 2) it could be expected, given the bias in recovery rates, that the highest values would be found at Misterton Carr. Since this site is the nearest of the six to the raw material source such an approach could prove highly detrimental in the examination of economization/ distance from source analyses.

Given the need for providing the basis for comparing the production characteristics of blades in such a way as to avoid or minimize the effects of variations in recovery standards the ratios of blade thickness to breadth were calculated for random samples drawn from the blade populations (table 13; fig. 45). It can be seen (fig. 45) that the results show a high level of similarity between the assemblages with the highest (relatively broader) mean value, 1:4.1, coming from Misterton Carr and the lowest (relatively narrower) mean value, 1:3.69, coming from Nab Water 3. More striking, perhaps, are the similarities in the measures of value dispersion (Coefficient of Variation - CV) for all of the assemblages with the exception of Deepcar (table 13). Whereas the other five assemblages have CV values falling between 0.30 and 0.33 Deepcar has a value of 0.23, reflecting a high degree of standardization and unimodality in the relative dimensions of blade breadth and thickness. This characteristic is readily apparent from a visual examination

	BLADES No.	BLADES Wt.	BLADES x̄.Wt	BREADTH/THICKNESS n	x̄	sd	v	cv	Total Blade Wt. / Total Tertiary Flake wt.	Total Blade No. / Total Tertiary Flake No.
MISTERTON CARR	217	175.2	0.81	100	4.10	1.27	1.59	0.31	.084	.221
UNSTONE 1	198	75.7	0.38	50	3.75	1.23	1.49	0.33	.149	.072
WARCOCK HILL NORTH	604	259.6	0.43	100	3.75	1.11	1.22	0.30	.132	.127
NAB WATER 3	167	105.2	0.63	50	3.69	1.19	1.38	0.32	.270	.177
LOMINOT 2/3	440	217.8	0.50	100	4.09	1.28	1.61	0.31	.157	.155
DEEPCAR	1984	1011.8	0.51	100	3.90	0.91	0.83	0.23	.207	.114

table.13

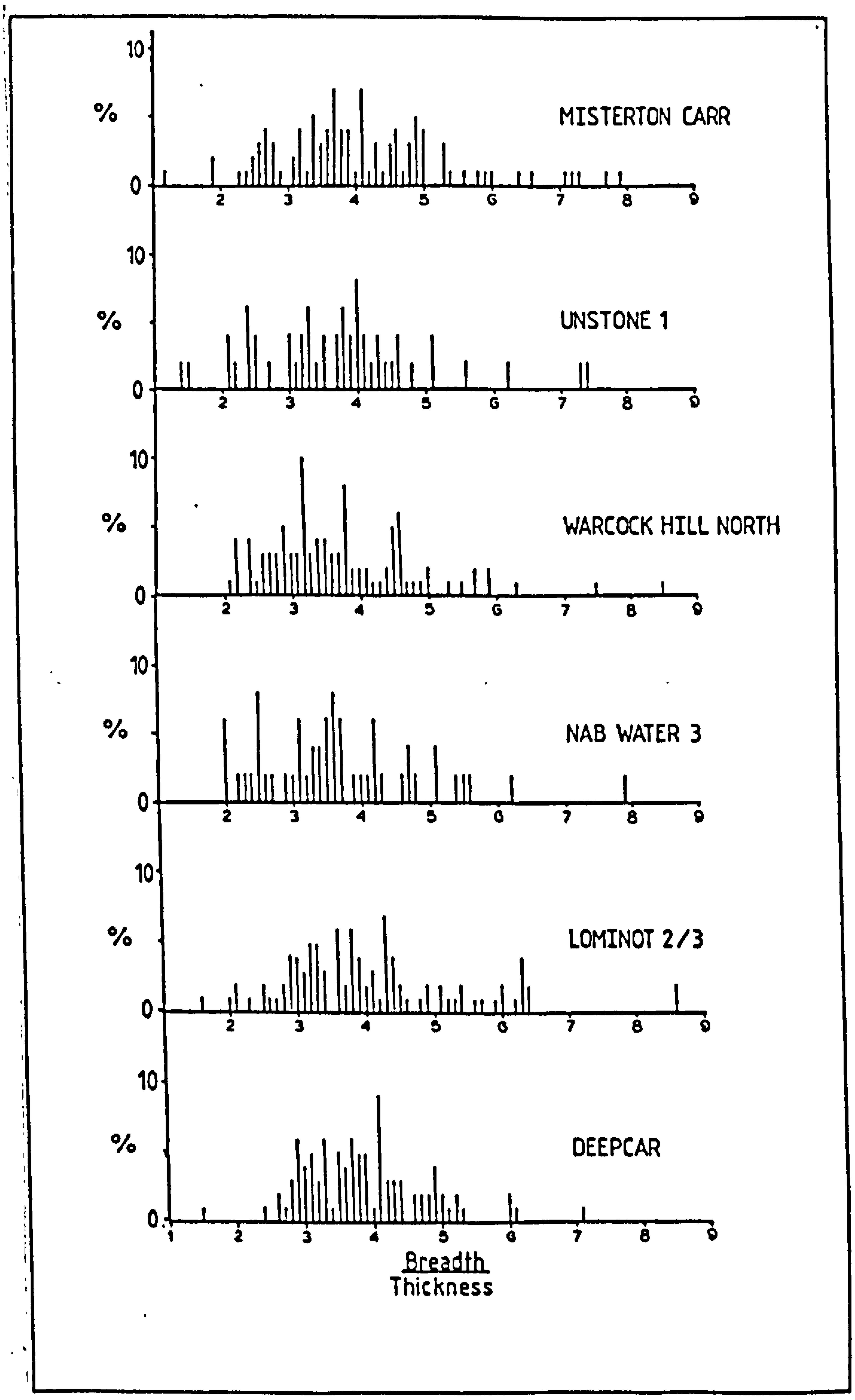


fig.45

	PLATFORM EDGE			CORE PLATFORM			CORE FACE RECOVERY			KEELED/RIDGE			Total Core Rejuv. Wt. / Total Flake Wt.	Total Core Rejuv. No. / Total Flake No.
	No.	Wt.	$\bar{x}$.Wt	No.	Wt.	$\bar{x}$.Wt	No.	Wt.	x.Wt	No.	Wt.	$\bar{x}$.Wt		
MISTERTON CARR	90	392.4	4.36	75	344.0	4.59	92	519.0	5.64	3	9.3	3.10	.250	.199
UNSTONE 1	32	41.3	1.29	8	21.2	2.65	50	123.7	2.47	?	?	?	.167	.030
WARCOCK HILL NORTH	113	167.8	1.49	91	227.5	2.50	59	158.5	3.64	10	20.2	2.02	.149	.049
NAB WATER 3	36	77.6	2.16	23	74.8	3.25	42	149.8	3.57	9	29.4	3.26	.361	.099
LOMINOT 2/3	71	130.7	1.84	17	73.7	4.34	46	203.7	4.43	4	12.2	3.05	.234	.045
DEEPCAR	202	272.7	1.35	73	208.1	2.85	388	1241.6	3.20	18	73.1	4.06	.257	.037

table.14

of the histograms for blade thickness to breadth ratios (fig. 45).

iv) Core maintenance/corrective debitage

The data on core maintenance/corrective debitage (table 14) once again provides some indication of the effects of differential recovery standards upon the debitage assemblages. The data has been broken down into four categories: core platform-edge removals, core platform removals, core face recovery flakes and ridge/keeled flakes. The absence of any of the latter from Unstone 1 reflects errors in the recording procedure rather than their actual absence from the assemblage.

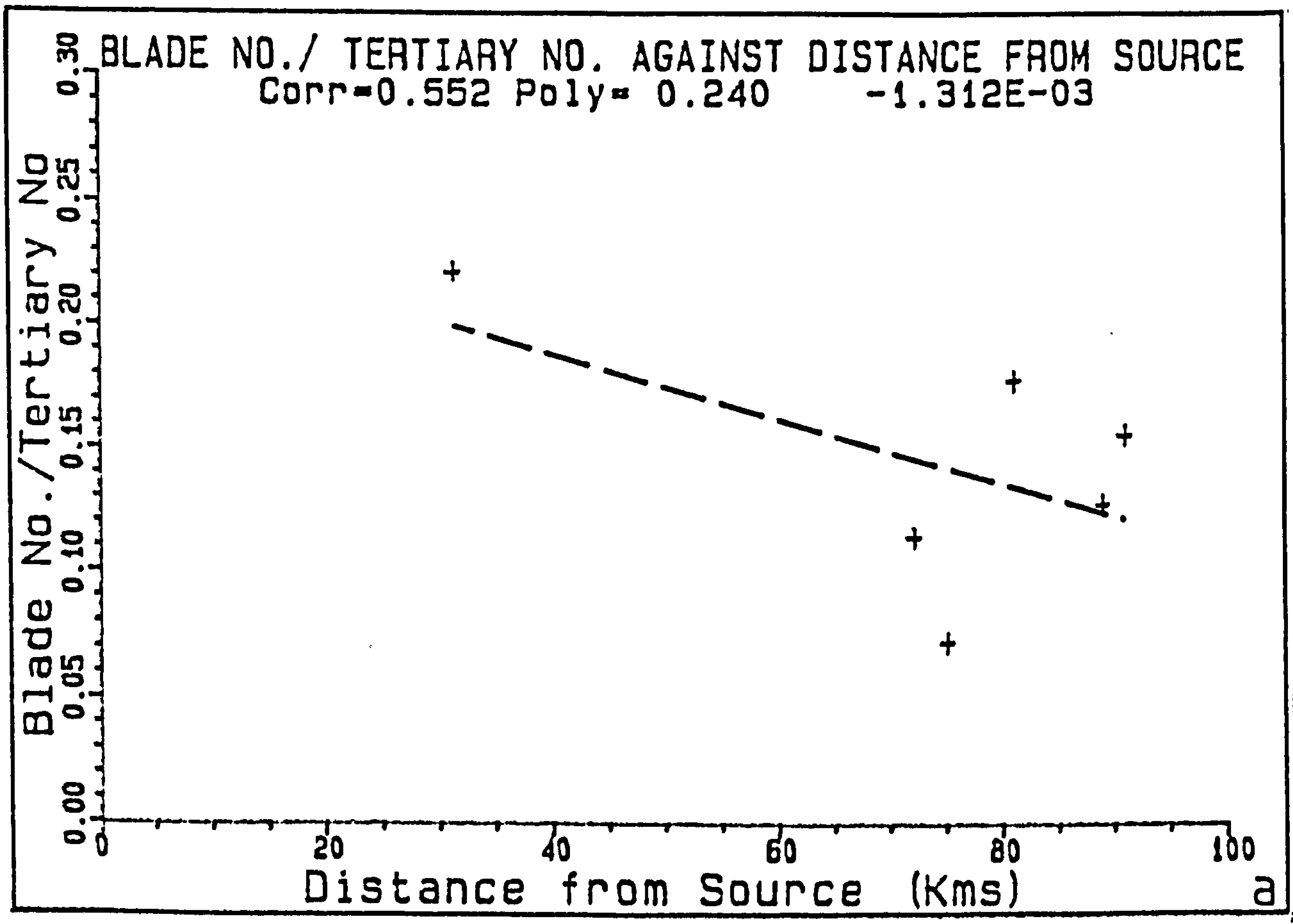
In all of the categories excepting ridge/keeled flakes the highest mean weight values come from Misterton Carr. Similarly, Unstone 1 produced the smallest values for core platform-edge and core face recovery flakes. In all of the assemblages, however, there are comparatively more core platform-edge removals than core platform removals although the relative frequencies vary between 4.2:1 at Lominot 2/3 to 1.2:1 at Misterton Carr. Similarly, the ratio between the combined core platform-edge and core platform removals frequency and the number of core face recovery flakes exhibits considerable variability ranging from 3.5:1 at Warcock Hill North to 0.7:1 at Deepcar. The relatively low numbers of ridge/keeled flakes is not surprising given that, in the reduction of a core, the initiation of new core faces might be expected to be a relatively infrequent occurrence by comparison to the various stages of maintenance/ recovery associated with existing core face usage.

c) Lithic economization and distance from source

Before examining aspects of the debitage data with a view to testing for correlations between increased distance from source and indices of lithic economization it is necessary to draw attention to the limitations of the sample. First, of the six assemblages none come from locations within thirty kilometres of the source area. Secondly, the site closest to the Wolds is Misterton Carr, an assemblage already noted for reflecting the poorest standard of assemblage recovery from amongst the sample. Ideally, the examination of lithic economization should incorporate a sample of assemblages presenting the full range of distances from the source along with an even or uniform standard of assemblage recovery. Clearly, neither of these desired preconditions are satisfactorily met in the present study. Nonetheless, it is believed that the present study does, within certain limits, provide a useful basis for examining certain aspects of lithic economization. In addition, the approach adopted may prove useful for future similar research either in the same region or in other areas.

In seeking to provide measures of lithic economization which may be regarded as independent or minimally influenced by recovery bias it has proven necessary to abandon certain 'obvious' indices, such as blade width, and adopt approaches that allow for size-range bias. Even so, it is accepted that the measures employed may be open to question on the grounds of variability in recovery standards.

Given the view on lithic reduction and economization outlined in chapter 2 it is clear that the production of blades, as opposed to flakes, might be seen as one strategy for obtaining more usable products from a given lithic mass. Accordingly, under conditions where increased distance from source incurred additional procurement costs we might, other things being equal, expect to observe a shift towards the production of blades with increasing distance. Given that, within this analysis, blades have been defined as being tertiary (i.e. dorsal faces exhibiting complete removal of natural surfaces) and that poor recovery standards increase the proportionate representation of larger primary and secondary flakes the indices adopted for measuring the relative frequencies and weights of blades/flakes have utilized the tertiary flake data. Two measures, total blade number divided by total tertiary flake number and total


BLADE NO./ TERTIARY NO. AGAINST DISTANCE FROM SOURCE
Corr=0.552 Poly= 0.240 -1.312E-03
Blade No./Tertiary No
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0
20
40
60
80
100
Distance from Source (Kms)
a

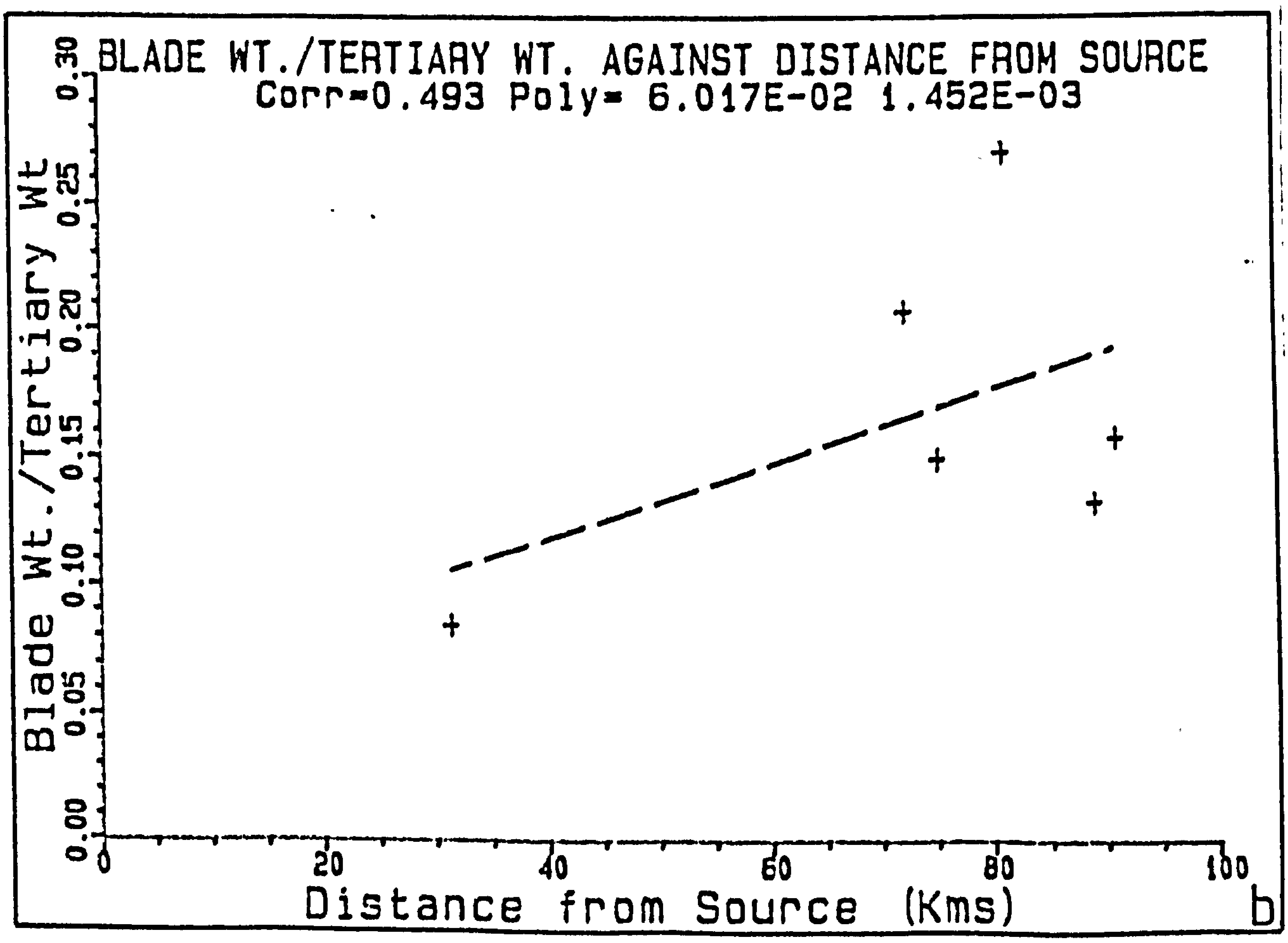
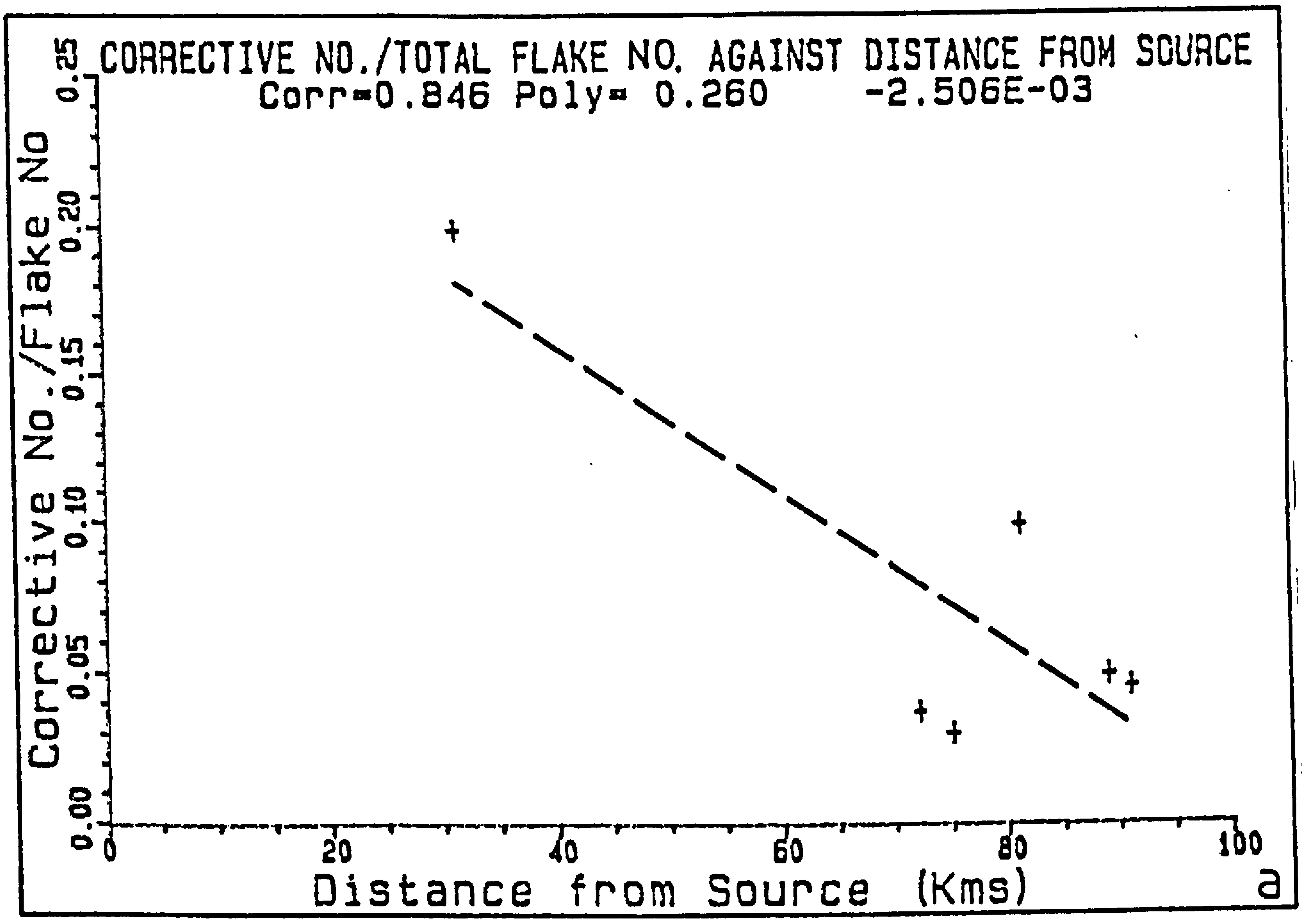

BLADE WT./TERTIARY WT. AGAINST DISTANCE FROM SOURCE
Corr=0.493 Poly= 6.017E-02 1.452E-03
Blade Wt./Tertiary Wt
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0
20
40
60
80
100
Distance from Source (Kms)
b

fig.46

blade weight divided by total tertiary flake weight, have been calculated for each assemblage (table 13) and correlated against distance from source (fig. 46). It can be seen that the indices of number (fig. 46a), far from indicating an increased proportion of blades with increasing distance, appear to suggest a decrease with increasing distance ($r = 0.552$) although the correlation is not statistically significant. The correlation by weight (fig. 46b) does appear to indicate an increase in blades ($r = 0.493$) with increased distance, although once again the correlation is not statistically significant.

With regards to the core maintenance/corrective debitage we might expect, under conditions where increasing distance incurs increased lithic procurement costs, to find increased efforts in the rejuvenation and maintenance of cores in order to prolong core utility. Accordingly, we might, other things being equal, expect to observe higher relative frequencies of core maintenance/corrective debitage compared to flakes with increased distance. Given that such corrective debitage incorporates large pieces, as reflected in the comparative mean weights of these and tertiary flakes, it was decided to adopt economization indices based upon dividing the total number and weight of core maintenance/corrective debitage by the total number and weight of primary, secondary and tertiary flakes (table 14), and correlate these with distance from source (fig. 47). The correlation by number (fig. 47a), far from revealing higher frequencies of core maintenance debitage with increased distance, strongly suggests a decrease with increased distance ($r = -0.846$) which is statistically significant at the 95% level (4 degrees of freedom). It must be noted, however, that without the value for Misterton Carr no clear correlation would exist.

The correlation by weight (fig. 47b) suggests no significant correlation ($r = -0.142$). Taken together it would certainly seem that, for the sample of sites used, the proportion of core maintenance/corrective debitage to flakes shows no increase with increased distance. The same


CORRECTIVE NO./TOTAL FLAKE NO. AGAINST DISTANCE FROM SOURCE
Corr=0.846 Poly= 0.260 -2.506E-03
Corrective No./Flake No
0.00
0.05
0.10
0.15
0.20
0.25
0
20
40
60
80
100
Distance from Source (Kms)
a

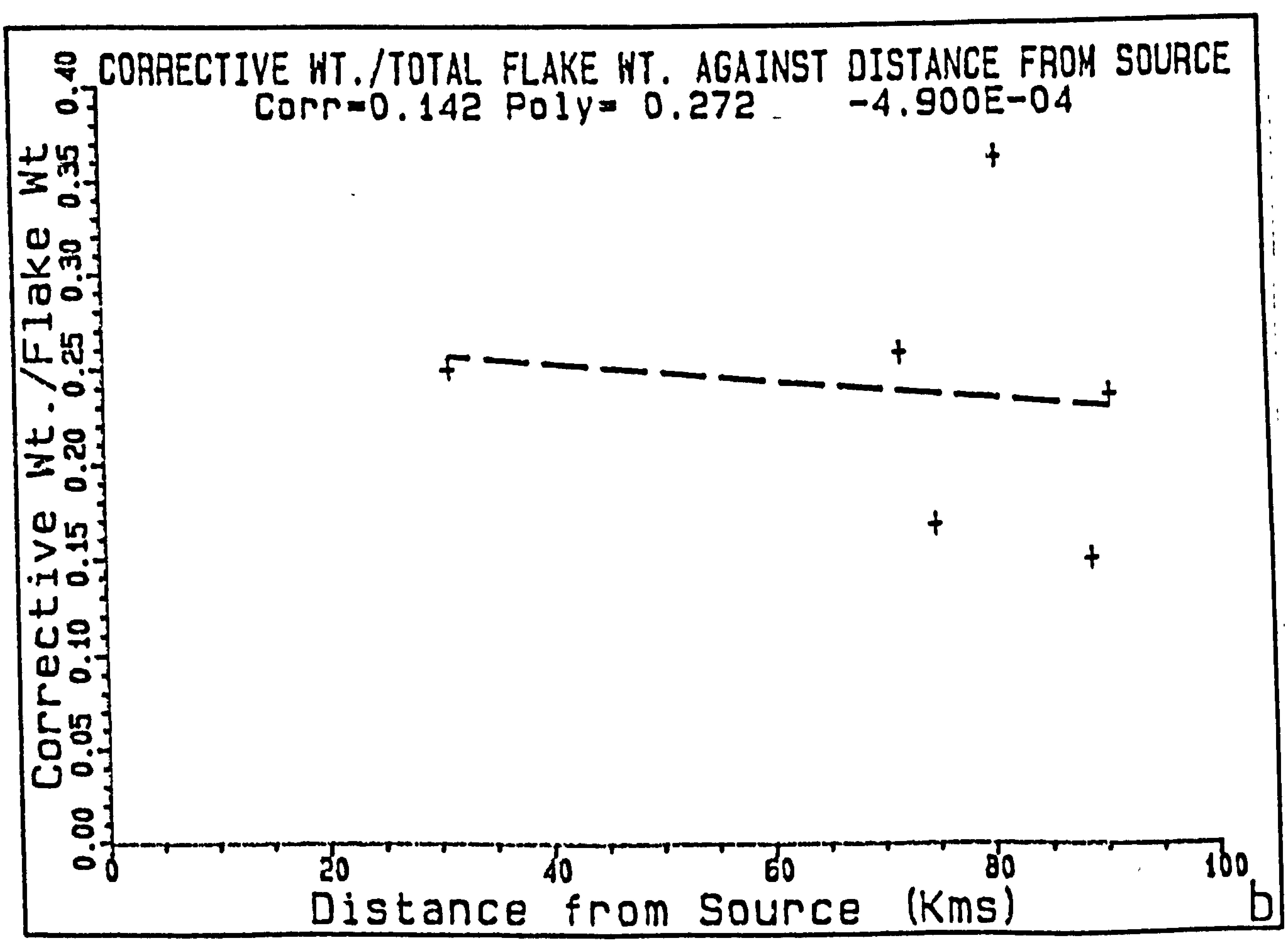
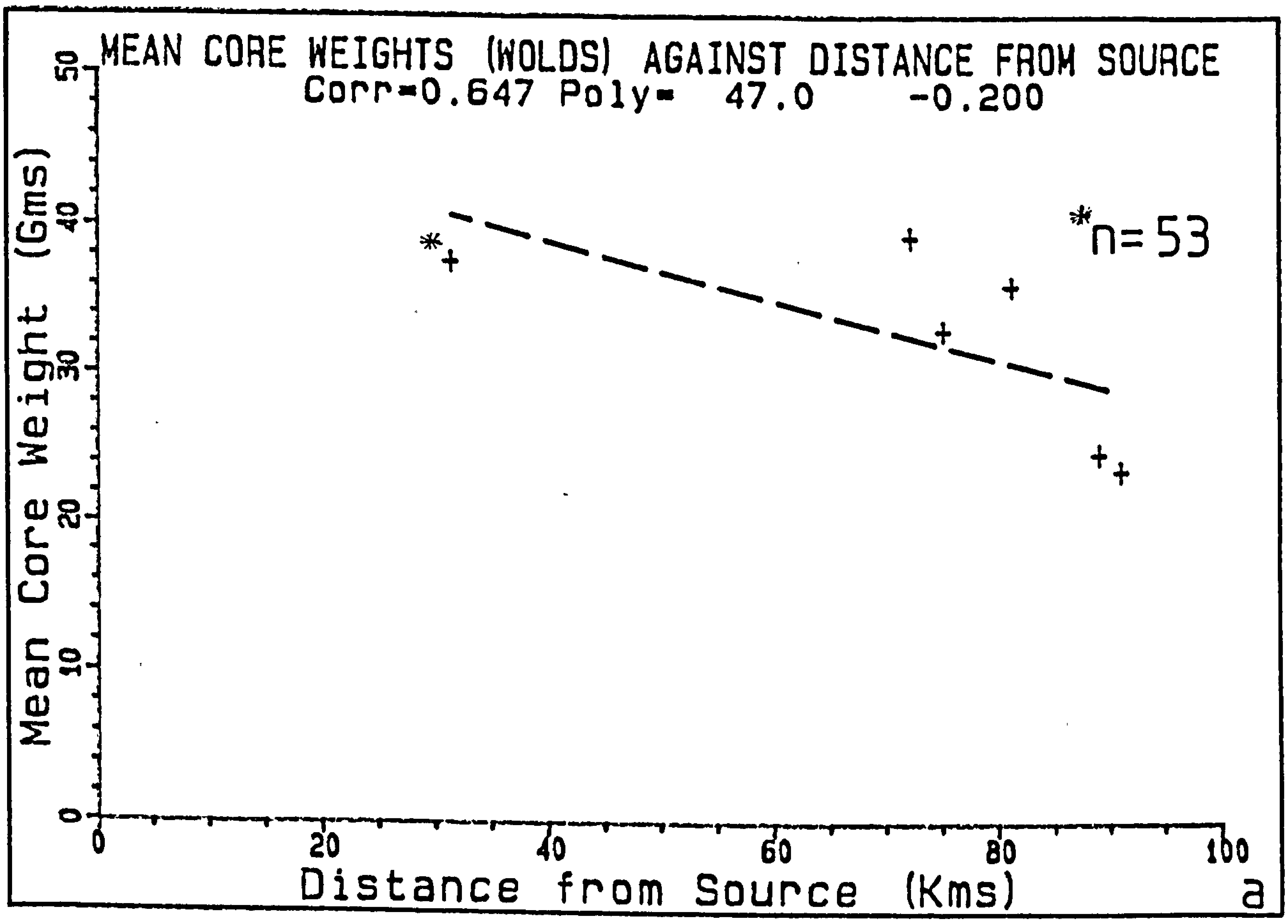

CORRECTIVE WT./TOTAL FLAKE WT. AGAINST DISTANCE FROM SOURCE
Corr=0.142 Poly= 0.272 -4.900E-04
Corrective Wt./Flake Wt
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0
20
40
60
80
100
Distance from Source (Kms)
b

fig.47


MEAN CORE WEIGHTS (WOLDS) AGAINST DISTANCE FROM SOURCE
Corr=0.647 Poly= 47.0 -0.200
*n= 53
Mean Core Weight (Gms)
0
10
20
30
40
50
0
20
40
60
80
100
Distance from Source (Kms)
a

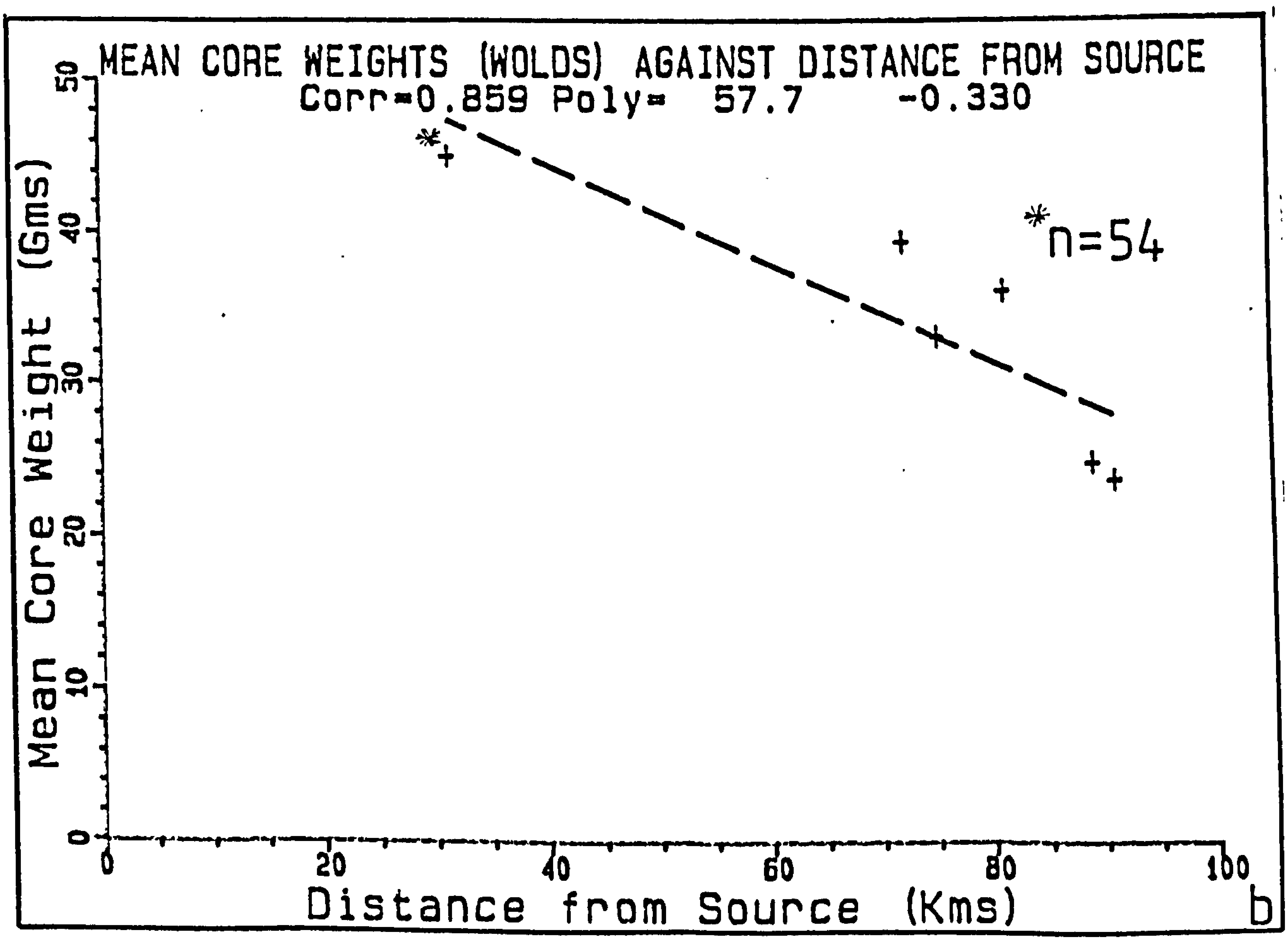

MEAN CORE WEIGHTS (WOLDS) AGAINST DISTANCE FROM SOURCE
Corr=0.859 Poly= 57.7 -0.330
*n=54
Mean Core Weight (Gms)
0
10
20
30
40
50
0
20
40
60
80
100
Distance from Source (Kms)
b

fig.48

conclusion may be applied to the blade data analysis.

In examining the core data it has been assumed that, other things being equal, increasing procurement costs arising from increased distance from source would promote the maintenance and continued reduction of cores. From this we might expect to observe relatively smaller/lighter cores at sites far from lithic sources in comparison with sites closer to such sources (see chapter 2). In presenting the data on core weights (table 12), as previously discussed, the presence of largely unworked flint masses at Misterton Carr was tabulated separately. Given the large size and weight of these masses the mean core weight value was calculated to exclude these and the preformed but unused cores. However, one of these preformed cores did fall in-between the criteria of inclusion as a preformed core and as a core. Consequently, two separate mean weight values were calculated for the cores, one excluding and one including this single very large piece (437 g). As a result, in correlating the mean weight of cores with distance two values for Misterton Carr have been used (fig. 48), and two separate correlation coefficients calculated (fig. 48a and b). The first correlation ($r = -0.646$) reveals a decline in mean core weights with increasing distance significant at the 80% level (4 degrees of freedom), whilst the inclusion of the previously mentioned core produced a correlation ($r= -0.859$) significant at the 95% level (4 degrees of freedom). With both measures, therefore, there would appear to be a significant decrease in core size with increased distance from source.

Discussion

From the analysis of Wolds flint debitage it would appear that conflicting results regarding distance from source/lithic economization have been achieved. None of the measures applied to blade and core maintenance data appear to indicate a cost/distance related reduction system, whilst the core data does appear to indicate that increased distance from source correlates with a reduction in core sizes.

Given the absence of a fall-off in Wolds flint percentages with increased distance a clear explanatory challenge exists. Although the majority of indices of lithic economization do not indicate a cost/distance related procurement mechanism how do we account for the core evidence? Under the pure embedded procurement model the temporally undifferentiated input of lithic supplies could be expected, other things being equal, to produce similar debitage patterns on sites occupied at different times of the year. From the analysis of debitage patterns, however, it appears that marked differences do exist between the assemblages. Most notably, from the study of the relative representation of primary, secondary and tertiary flakes (fig. 41) and the evidence of the sizes of primary flakes (fig. 42) it appears that Misterton Carr exhibits a range of large primary and secondary (table 10; fig. 43c and d) flakes not represented at the other sites.

Similarly, Misterton Carr produced a series of largely unmodified flint masses and prepared, but unutilized, cores of Wolds flint. None of the other assemblages contained such evidence. At Deepcar a single nodule of brown translucent flint, weighing 58.2 g, with just one flake removed was noted, but no such examples of Wolds flint were present. Taking the flake and core data together, therefore, it would appear that the Misterton Carr assemblage contains evidence for the collection and initial reduction/preparation of Wolds flint masses for use as cores which is not present at the other sites. Further support for such an interpretation may be found in the presence of large core platform removals (fig. 43e) at Misterton Carr, reflected in the high mean weight value for core platform removals (table 14) in comparison with the other assemblages. Such differential patterning in the organization of lithic reduction would not appear to fit comfortably with the expectations of the pure embedded model of lithic procurement.

Evidence for differential patterning in lithic debitage extends beyond the contrast between Misterton Carr and the other sites. The analysis of blade breadth/thickness ratios revealed (table 13; fig. 45) that the Deepcar assemblage contains blades which fall within a narrower range of variability than was observed for the other sites. Whilst it might be argued that the production of blades conforming to a more standardized set of dimensional relationships could reflect greater care (and, by extension, greater economy) in manufacturing such a view could not explain the apparent similarity in values noted for Misterton Carr and those for sites most distant from the source area (i.e. Warcock Hill North, Lominot 2/3).

In other words, taken together, whilst the evidence for differential patterning in debitage does not conform to our expectations for cost/distance related procurement models, neither does it conform to the expectations of the pure embedded model. As discussed in chapter 2 measures of lithic economization may, instead of relying upon debitage analyses, employ analyses of retouched tool categories where increased rates of curation through resharpening or reshaping of the tool form would effectively reduce the sizes of such tools prior to discard. From this it follows that tool forms such as end-scrapers or tranchet-axes should, under cost/distance constrained procurement systems, show a decrease in sizes with increased distance from source. However, by examining the lengths of end-scrapers from the six assemblages (fig. 49) it appears that no differences in the lengths exist for Misterton Carr or sites most distant from source such as Warcock Hill North and Lominot 2/3. Similarly, tranchet-axe dimensions (table 15) are no smaller in the Pennine and Peak districts than those from Lincolnshire and Nottinghamshire. We might note that, at present, only one tranchet-axe sharpening flake is known from the Pennines (Radley and Marshall 1965), further emphasizing the paucity of evidence for intensive maintenance of such tools in the region. Once again, there would appear to be little evidence to suggest constrained raw material supplies.

Given the evidence considered thus far it would seem that it is necessary to look beyond cost/distance constrained and pure embedded models of lithic procurement. In turning

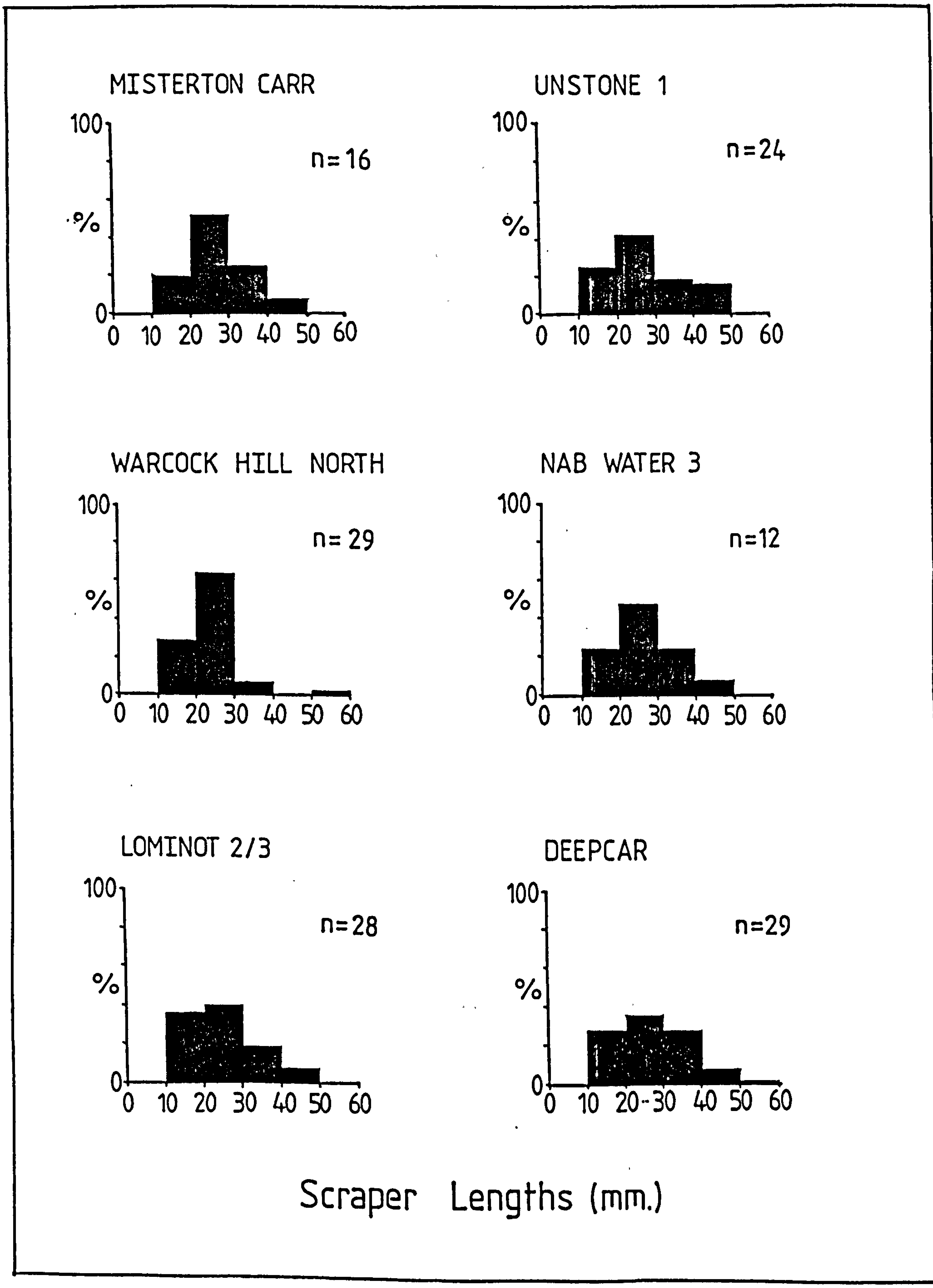

MISTERTON CARR
n=16
UNSTONE 1
n=24
WARCOCK HILL NORTH
n=29
NAB WATER 3
n=12
LOMINOT 2/3
n=28
DEEPCAR
n=29
100
%
0
0 10 20 30 40 50 60
Scraper Lengths (mm.)

fig. 49

LINCOLNSHIRE/NOTTINGHAMSHIRE	L.	(mms) Br.	Th.	(gms) Wt.
SOUTH RAUCEBY (SK 993445)	126	48	30	-
MISTERTON CARR (SK 728950)	78	43	19	81.3
MISTERTON CARR (SK 728950)	124	52	27	167.7
MISTERTON CARR (SK 729951)	76	25	20	43.9
MISTERTON CARR (SK 728950)*	193	55	47	-
DERBYSHIRE				
STONEY LOW (SK 174674)	90	40	-	-
LATHKILL DALE (SK 181657)	80	30	-	-
KENSLOW (SK 184616)	140	60	-	-
WEST RIDING OF YORKSHIRE				
BARKISLAND (SE 048183)	168	70	38	590.0
NETHERTON (SE 278164)	174	50	37	-
ICKORNSHAW MOOR(SD 971394)	165	56	28	-

* = 'tranchet - pick'

TRANCHET AXE DIMENSIONS IN STUDY AREA

table.15

to consider the developed embedded model, therefore, there is a need to bear in mind some of the implications identified previously concerning the new model of Earlier Mesolithic subsistence and settlement.

d) The developed embedded procurement model

Under the developed embedded procurement model and within the new model of Earlier Mesolithic subsistence and settlement we must envisage a situation where the principal inputs of lithic materials occurred during the course of generalist food procurement activities in the lowlands. The postulated shift in subsistence strategies away from the generalist strategies of spring and summer towards specialist, intercept hunting in the uplands and upland valleys during autumn raises the problem of how lithic technology could be organized in order to prevent conflicts in technological and subsistence time allocations.

The observed patterning in reduction evidence suggests that at least one major difference exists between the low-lying site of Misterton Carr and the Pennine assemblages. At Misterton Carr there is clear evidence for inputs of virtually unmodified Wolds flint masses and the initial reduction and preparation of these masses for use as cores. The absence of such evidence in the Pennines further suggests that these initial stages in lithic reduction were being undertaken elsewhere. If we put these observations together it can be suggested that cores were being prepared at sites such as Misterton Carr and transported to the Pennines.

Might we not expect, however, the costs of transporting large cores to the Pennines to promote greater economization in their use, and would not such a system effectively constrain raw material supplies in the Pennines? Given that the envisaged shift in settlement from the lowlands to the uplands is part of the subsistence strategy and that such mobility would be undertaken for subsistence goals then we must answer no! Just as embedded inputs of lithics during the course of logistical mobility incur no additional costs because the mobility is scheduled within subsistence activity then, equally, the transportation of prepared cores as part of the subsistence related mobility during aumtumn would incur no additional costs. The anticipatory preforming and transportation of prepared cores, in other words, is embedded in subsistence mobility.

Why, therefore, engage in the preforming of cores prior to such mobility? Why not simply transport the unmodified nodules? Quite apart from the benefits of reducing the weight of the flint the answer may lie in the need for ensuring the mechanical adequacy of the material prior to transportation. We have already noted that Wolds flint may vary considerably in its mechanical properties. The initial preparation of cores may, in part, have provided an insurance against transporting nodules of poor mechanical properties. That hunter-gatherer lithic reduction strategies may respond to demand periodicity and spatial positioning within regions (Binford and O'Connell 1985: 428) represents another important insight into inter-assemblage variability. Within the present context the need to ensure that the time-stressed intercept hunting of autumn did not suffer from technological ill-preparedness may have promoted this anticipatory core preparation.

We may, therefore, account for the variations in the core and primary flake data and in the data for core maintenance debris within the developed embedded model. The evidence for the preparation and subsequent transportation of large cores in response to anticipated demands for technology does not, however, account for the variability in the degree of dimensional standardization noted for blades. Why does blade production at Deepcar differ from the other assemblages?

Within the subsistence and settlement model under consideration the shift in activities and location towards the Pennines, and other upland regions, is connected with a period of intensive, specialized hunting. From the discussion of intercept strategies emphasis was given to the need for adequate technological preparation. The gearing-up of hunting technology in anticipation of demand during intercept hunting periods creates a marked contrast to the organization of hunting technology for use in encounter strategies. In place of the steady maintenance/replacement of existing projectiles anticipated under the latter, intercept hunting - especially when connected with producing surplus supplies for over-wintering - might be expected to be preceded by the manufacture of additional projectiles for subsequent use.

Archaeologically, we can expect a significant contrast in the evidence of projectile manufacture/replacement rates between sites where projectile technology was being maintained at a pre-existing level and sites where there was an anticipatory gearing-up of such technology in anticipation of the autumnal intercept hunt. This contrast would be expected not only between the sites occupied during spring/summer (generalist encounter hunting) and autumn (specialized intercept hunting) but also between sites occupied during the autumnal strategy. The embedded production strategies connected with the autumnal intercept hunt would, given the need to avoid conflicts in subsistence and technological time allocations, promote an initial intensive period of projectile manufacture followed by the subsequent maintenance of such technology. In other words, sites occupied as part of the autumnal strategy could be expected to be differentiated into those occupied during the initial, preparatory phase and those occupied during the actual execution of the hunting strategy. This division in autumnal sites may correspond with the behavioural distinction between residential sites and logistical field camps/hunting locations.

In terms of Earlier Mesolithic technology how might we provide a measure of manufacturing/replacement rates for lithic projectiles? As noted previously, microliths were manufactured from blades with the use of the micro-burin technique. This technique involved the initial notching of a blade, either just below the proximal and/or just above the distal end, in order to facilitate the controlled removal of the proximal and/or destal end(s) of the blade and to leave a microlith preform or blank with edges suitable for retouching into the final form.

In providing an index of microlith manufacture rates it is important to note that whereas simple obliquely-blunted points required the detachment of just the bulbar end the manufacture of isosceles triangles, trapezoids, elongated trapezoids and Horsham points may have demanded the removal of both the bulbar and distal blade segments (fig. 50). From this it follows that the ratio of micro-burins to manufactured microliths will vary according to the types of microlith being manufactured. Quite clearly, therefore, in comparing microlith manufacture rates for different assemblages the types of microlith being produced need to be considered. Similarly, if we wish to establish a measure of manufacturing/replacement rates for microliths by comparing the numbers of discarded microliths to micro-burins we need to establish the number of proximal and distal micro-burins in order to allow for the different ratios of micro-burin to microlith resulting from manufacture.

The potentially misleading view of microlith manufacturing/replacement rates resulting from a failure to distinguish between differing micro-burin to manufactured microlith ratios can be seen from the work of Jacobi (1978a) where a series of 'Star Carr-type' assemblages were under discussion. At the sites of Pointed Stone 2 and 3 Jacobi noted that the ratios of micro-burins to microliths were 2:1 and 1.1:1 respectively. In interpreting this evidence it was claimed that this demonstrated some form of gearing-up in the anticipation of future hunting (315). Being from sites of 'Star Carr-type' the microliths being manufactured included large numbers of isosceles and trapezoidal microlithic forms. It is interesting to note that of some 22 illustrated micro-burins (Jacobi 1978a: fig. 7) from Pointed Stone 3 half are bulbar and half are distal micro-burins. Quite clearly, therefore, the actual number of microliths manufactured at Pointed Stone 3 may be half the total number of micro-burins.

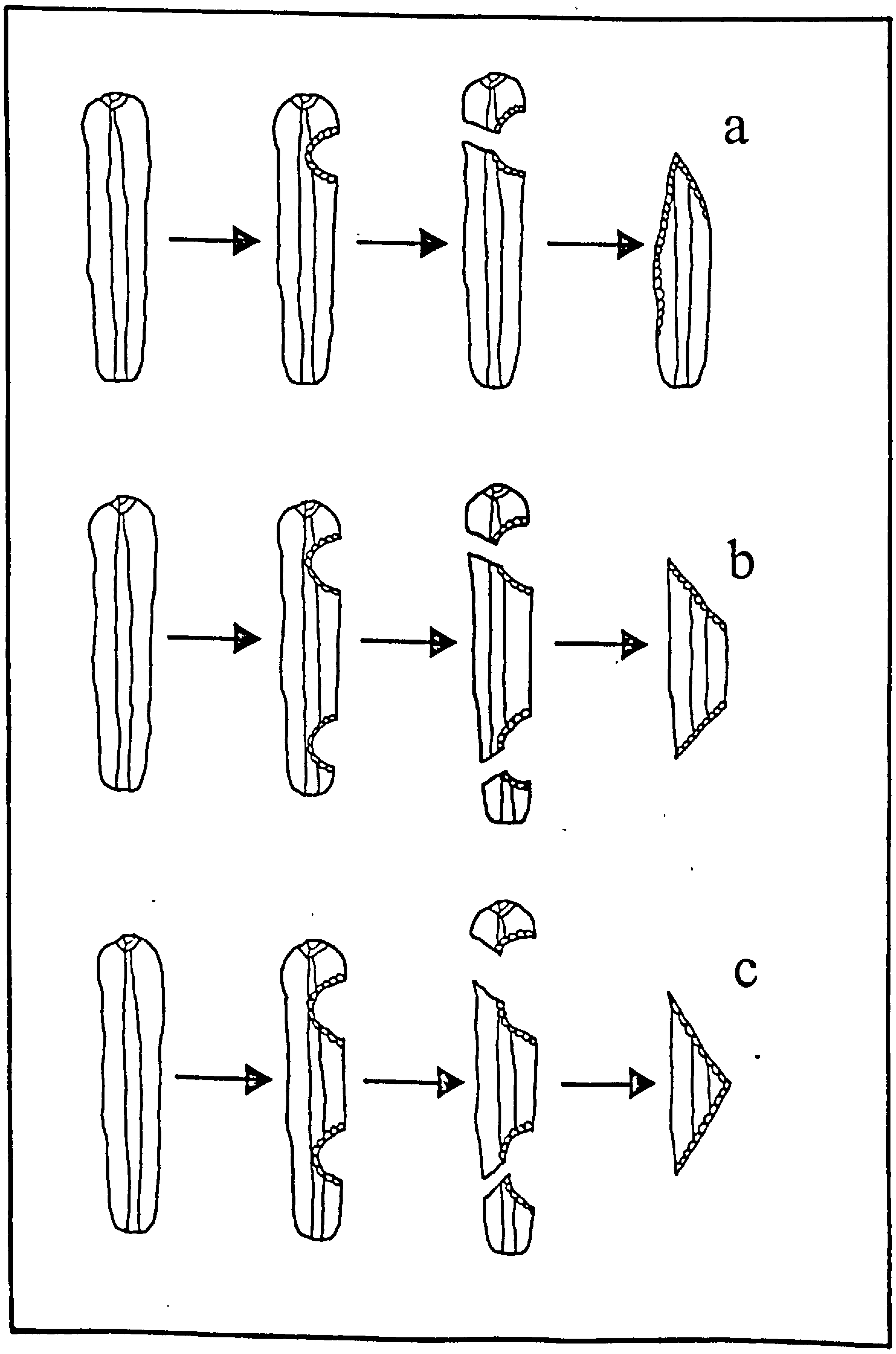


fig. 50

In contrast, assemblages of 'Deepcar-type' are dominated by variants of simple obliquely-blunted points and are noted for the virtual absence of isosceles or trapezoidal forms. Consequently, whereas the micro-burin to manufactured microlith ratio for 'Star Carr-type' assemblages may be in the order of 2:1 the ratio for 'Deepcar-type' assemblages will be in the order of 1:1. Confirmation of such a view can be found in the ratio of bulbar to distal micro-burins at Deepcar (Radley and Mellars 1964: 9) where, excluding double-ended and mis-hit/unfinished forms, a ratio of 18:1 was originally observed. In fact, the analysis of lithic debitage at Deepcar revealed 5 additional bulbar micro-burins creating a ratio of 19 bulbar to every 1 distal micro-burin. Clearly, therefore, 'Deepcar-type' assemblages may be generally regarded as containing evidence for the production of one micro-burin for every microlith manufactured.

In order to examine the evidence for microlith manufacture/replacement rates the ratios of microliths and micro-burins, expressed as percentages, have been calculated for 'Deepcar-type' assemblages and illustrated (fig. 51). From this it can be seen that of these assemblages only Deepcar contains evidence for the manufacture of more microliths than were deposited. Whilst it is certainly true that some of the Deepcar micro-burins are very small it must also be noted that many of the microliths were fragmentary and also very small. Even if we exercise caution and bear in mind the differential recovery standards for Mesolithic excavations it is remarkable that no other Earlier Mesolithic assemblage has produced clear evidence for the manufacture of more microliths than were deposited.

If it is accepted that Deepcar does contain evidence suggesting the anticipatory gearing-up of hunting technology and that such evidence does not appear at any other Earlier Mesolithic site in the study area then clearly the expectations of the new model of Earlier Mesolithic subsistence and settlement for the organization of technology

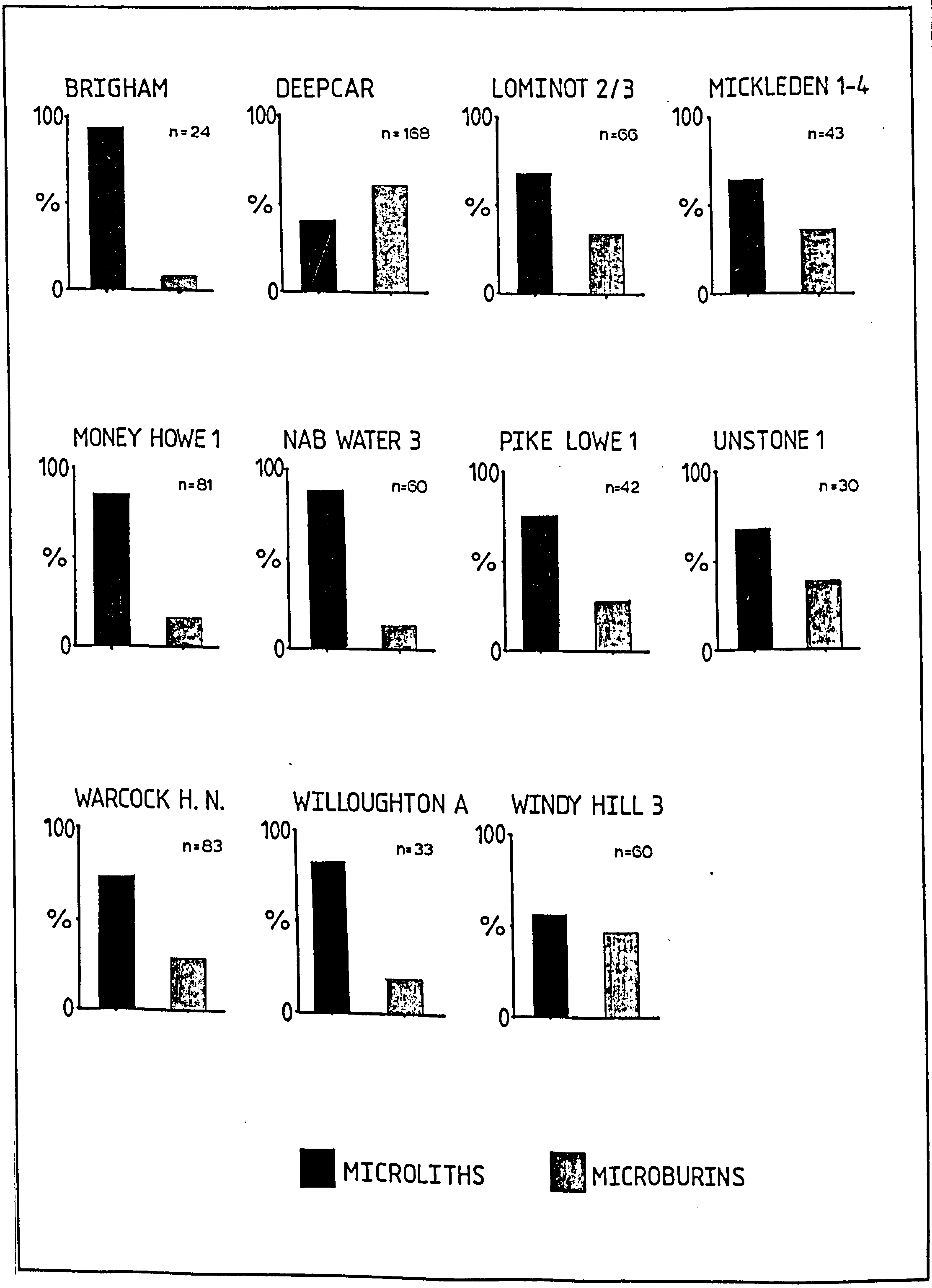

BRIGHAM
n=24
DEEPCAR
n=168
LOMINOT 2/3
n=66
MICKLEDEN 1-4
n=43
MONEY HOWE 1
n=81
NAB WATER 3
n=60
PIKE LOWE 1
n=42
UNSTONE 1
n=30
WARCOCK H. N.
n=83
WILLOUGHTON A
n=33
WINDY HILL 3
n=60
100
%
0
MICROLITHS
MICROBURINS

fig. 51

are met. Deepcar, situated on a spur of land within one of the major valley systems leading to the Pennine uplands, may have provided a residential location where the hunting technology was prepared in anticipation of the autumnal intercept strategy. The previously noted structural evidence at the site would accord with such a view.

Given the emphasis upon gearing-up at Deepcar the production of blades conforming to a more standardized set of morphological attribute relationships (fig. 45) may be understood as reflecting the relatively greater level of blade production for microlith manufacture. To this we might also add that from the core weight data (table 13; fig. 44) it was apparent that the mean core weight at Deepcar was somewhat greater than that noted for the other Pennine assemblages. If Deepcar served as a location for the gearing-up of hunting technology then we could expect to see prepared cores being introduced to the site from sites such as Misterton Carr. Following the use of the cores in the manufacture of microlithic and other maintenance/craft-related tool forms some of these cores will have been taken by task groups into the uplands for further reduction in the maintenance of hunting equipment and for the production of tools for maintenance/craft activities. Such a sequence of reduction would help to account for the observed pattern in core weights.

By the same argument, given that the anticipatory, collector-type mobility will have introduced or promoted high levels of spatial redundancy in the settlement system some cores may have been left or deliberately cached at Deepcar for use in future visits. Once again, such behaviour would serve to produce the observed pattern in core weights.

To what extent can we identify additional evidence in the Deepcar assemblage for such gearing-up of hunting technology? The presence of notched flakes, generally interpreted as shaft-straighteners, might be expected if hunting technology were being manufactured. In this respect it is interesting to note the observations of Radley and Mellars (1964) on the Deepcar assemblage:

> 'Many notched pieces - possibly hollow scrapers - were found and a large number of flakes showing clear signs of heavy wear.'
>
> (12).

Whilst the typological criteria for defining notched flakes are, perhaps, not as clear as for other tool categories, such as microliths and scrapers, the presence of large numbers of such pieces at Deepcar, particularly in view of the other evidence for gearing-up of hunting technology, may be significant.

5) <u>Conclusions for the Earlier Mesolithic</u>

The analysis of lithic debitage and the consideration of lithic procurement mechanisms would appear to lend support to the developed embedded model. The observed patterns meet the expectations of a lithic procurement system where the input of embedded lithic supplies varied in quantity throughout the annual subsistence schedule. In the context of the model of subsistence and settlement outlined in this and previous chapters the evidence for differential structuring in the organization of reduction stages between Misterton Carr, Deepcar and the other upland sites may be understood as technological responses avoiding conflicts in time allocation with subsistence schedules.

Given the importance of these results for perspectives on Earlier Mesolithic adaptations it seems appropriate to integrate the various subsistence, settlement and technological implications within a single descriptive model (fig. 52). One of the most striking aspects of this model is the elegant balance in subsistence and technological organization. In particular, there appears to be a remarkable set of embedded raw material, both lithic and antler, input 'events' which serve as the basis for anticipated technological requirements. The spring/summer subsistence strategies result in a steady embedded supply of lithic raw materials. Whilst some of these

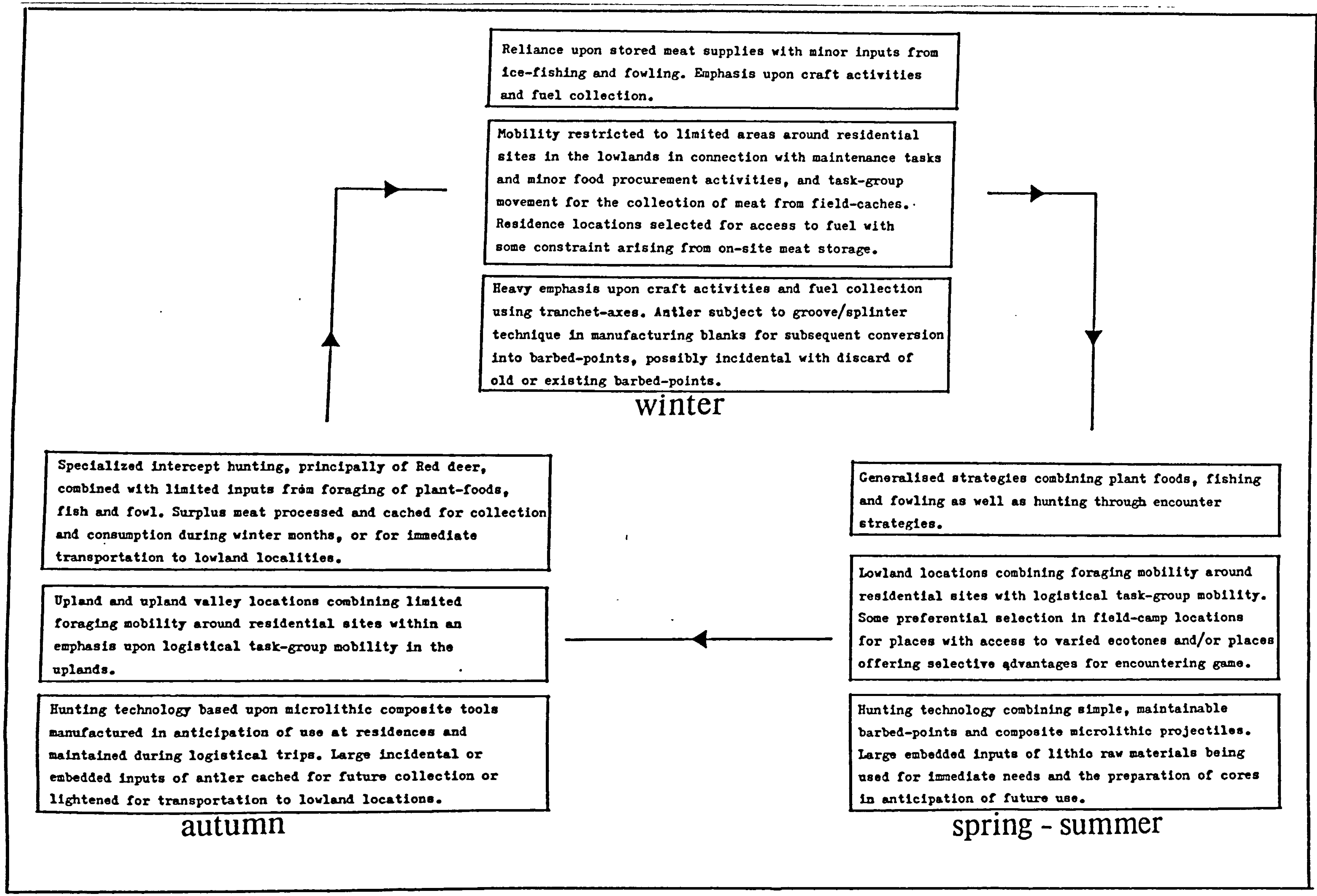

Reliance upon stored meat supplies with minor inputs from ice-fishing and fowling. Emphasis upon craft activities and fuel collection.
Mobility restricted to limited areas around residential sites in the lowlands in connection with maintenance tasks and minor food procurement activities, and task-group movement for the collection of meat from field-caches. Residence locations selected for access to fuel with some constraint arising from on-site meat storage.
Heavy emphasis upon craft activities and fuel collection using tranchet-axes. Antler subject to groove/splinter technique in manufacturing blanks for subsequent conversion into barbed-points, possibly incidental with discard of old or existing barbed-points.
winter
Specialized intercept hunting, principally of Red deer, combined with limited inputs from foraging of plant-foods, fish and fowl. Surplus meat processed and cached for collection and consumption during winter months, or for immediate transportation to lowland localities.
Upland and upland valley locations combining limited foraging mobility around residential sites within an emphasis upon logistical task-group mobility in the uplands.
Hunting technology based upon microlithic composite tools manufactured in anticipation of use at residences and maintained during logistical trips. Large incidental or embedded inputs of antler cached for future collection or lightened for transportation to lowland locations.
autumn
Generalised strategies combining plant foods, fishing and fowling as well as hunting through encounter strategies.
Lowland locations combining foraging mobility around residential sites with logistical task-group mobility. Some preferential selection in field-camp locations for places with access to varied ecotones and/or places offering selective advantages for encountering game.
Hunting technology combining simple, maintainable barbed-points and composite microlithic projectiles. Large embedded inputs of lithic raw materials being used for immediate needs and the preparation of cores in anticipation of future use.
spring - summer

fig.52

supplies are employed in the production and maintenance of tools for use during spring/summer the remaining supplies are used in the preparation of cores whose use is anticipated during the time and efficiency stressed autumnal strategy.

With autumn come the specialized intercept strategies designed to produce the food supplies for over-wintering. The heavy and intensive demand upon microlithic hunting equipment, whilst undoubtedly resulting in a depletion of both projectiles and lithic supplies, produces, as an incidental by-product, large quantities of antler. This antler provides the raw materials, at no additional cost, for the production of barbed points for use in the following spring and summer. Processing of the antler and transportation to winter residences is embedded in the settlement system, and is partially facilitated by the reduction in subsistence related demands upon technology during winter. In this way, the subsistence activities and hunting strategies of both spring/summer and autumn provide complementary embedded inputs of raw materials for technology.

Such a model, it is argued, not only accounts for the economic, settlement and lithic technology patterns observed from the archaeological record but also successfully integrates the lithic and non-lithic hunting technology within one behavioural system. From the distribution of evidence for barbed points and barbed point manufacture (fig. 53) additional support for this model may be claimed. The only findspots in upland contexts, at Dowel Cave (Bramwell 1959: 101) and Porth-y-waen (Britnell 1984: 385), refer to individual barbed points both of which are broken or damaged examples. Both in terms of numbers of barbed points and evidence for their manufacture there is a clear lowland emphasis.

The importance of this model lies not only in its implications for understanding the Earlier Mesolithic but also in providing a behavioural account which acts as a base-line for contrasting with the Later Mesolithic

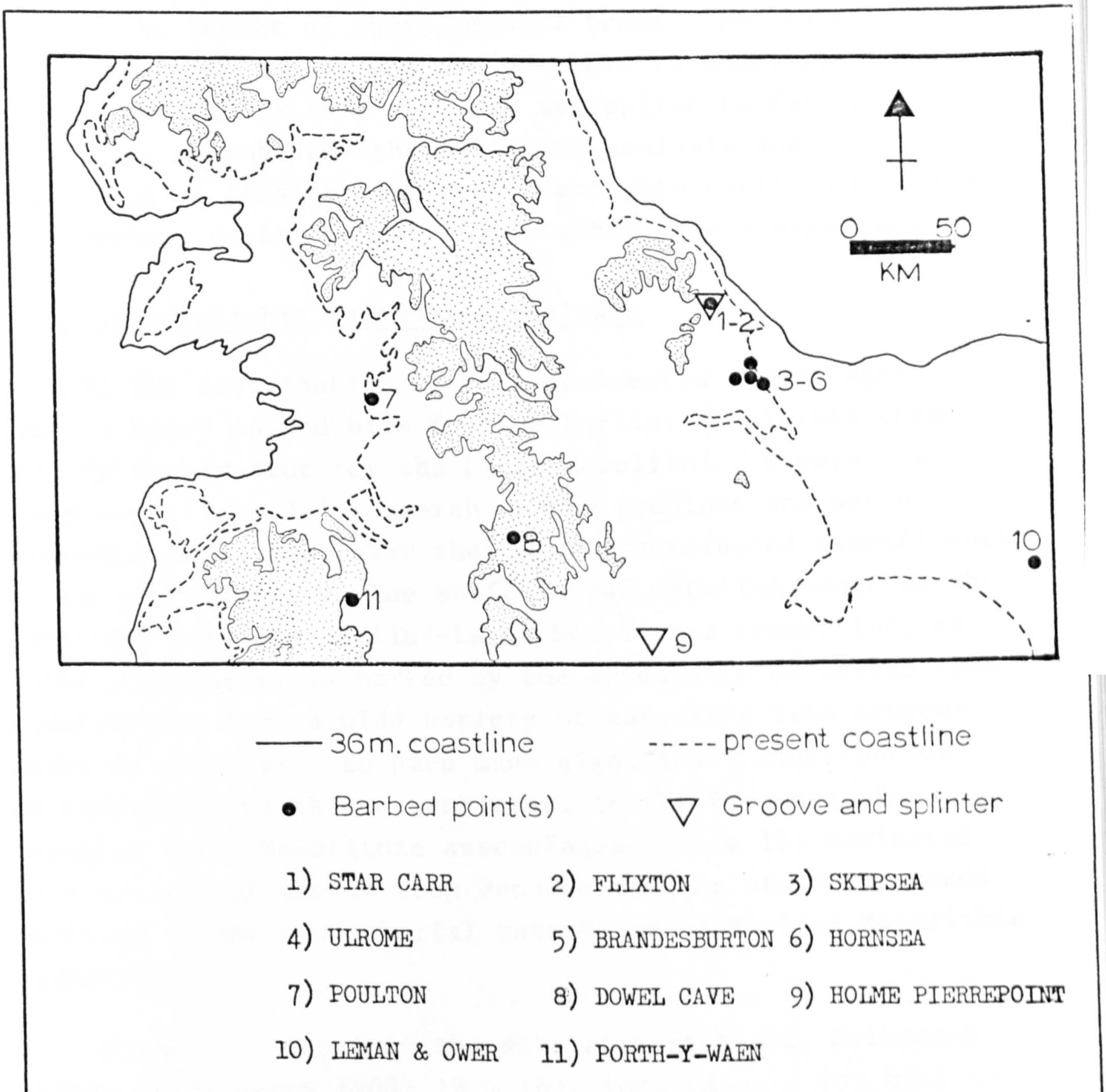

0
50
KM
1-2
3-6
7
8
9
10
11
36m. coastline
present coastline
Barbed point(s)
Groove and splinter
1) STAR CARR
2) FLIXTON
3) SKIPSEA
4) ULROME
5) BRANDESBURTON
6) HORNSEA
7) POULTON
8) DOWEL CAVE
9) HOLME PIERREPOINT
10) LEMAN & OWER
11) PORTH-Y-WAEN

fig.53

archaeological record. As discussed in the previous chapters the Later Mesolithic witnessed changes in settlement patterns and technology which may, in part, reflect the impact of environmental trends upon subsistence schedules. Although it was not possible to undertake the sort of detailed lithic analyses as applied to Earlier Mesolithic assemblages the following analysis and discussion do provide some useful and potentially significant observations on Later Mesolithic technological organization.

6) Later Mesolithic assemblage analysis

If the distribution of well documented assemblages shows a heavy upland bias for the Earlier Mesolithic then this is doubly true for the Later Mesolithic. Within the study area (fig. 54) research in the Pennines and North Yorkshire Moors has, over the years, contributed significantly to our understanding. The shift in raw material usage which coincides with the Earlier-Later Mesolithic transition, as noted previously, is marked by the appearance of assemblages manufactured from a wide variety of materials from sources which do not appear to have made significant contributions to Earlier Mesolithic assemblages. In the Pennines, for example, Later Mesolithic assemblages (table 16) dominated by a variety of cherts from Pennine sources stand in marked contrast to the raw material patterning of Earlier Mesolithic assemblages.

Beyond the Pennines the site at Castle-Pit, Melbourne (Lomas 1959; Manby 1963: 13 - 16), located on a low hill to the south of the River Trent, provides further indications of changing raw material use. Within this surface-collected assemblage it is possible to recognize both Earlier and Later Mesolithic flintwork. Of five microliths four are Later types (Manby op. cit.: fig. 4, nos. 1 - 3 and 5) whilst the remaining microlith is a typical Earlier Mesolithic obliquely-blunted point with opposed retouch at the tip (Manby op. cit.: fig. 4, no. 4). Significantly, the latter is made from Wolds flint whereas the Later types are of translucent flint varieties. Within the assemblage

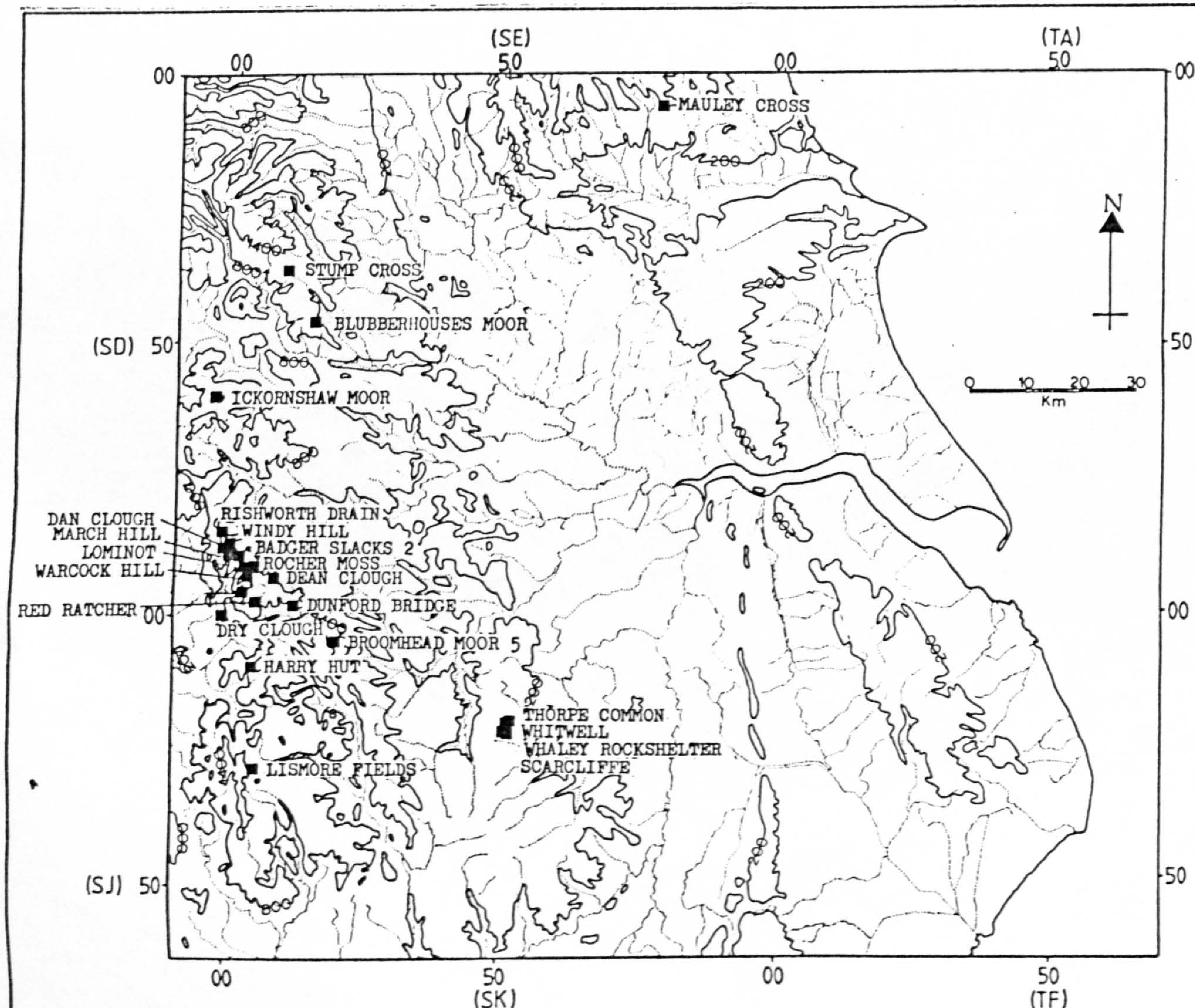


fig.54

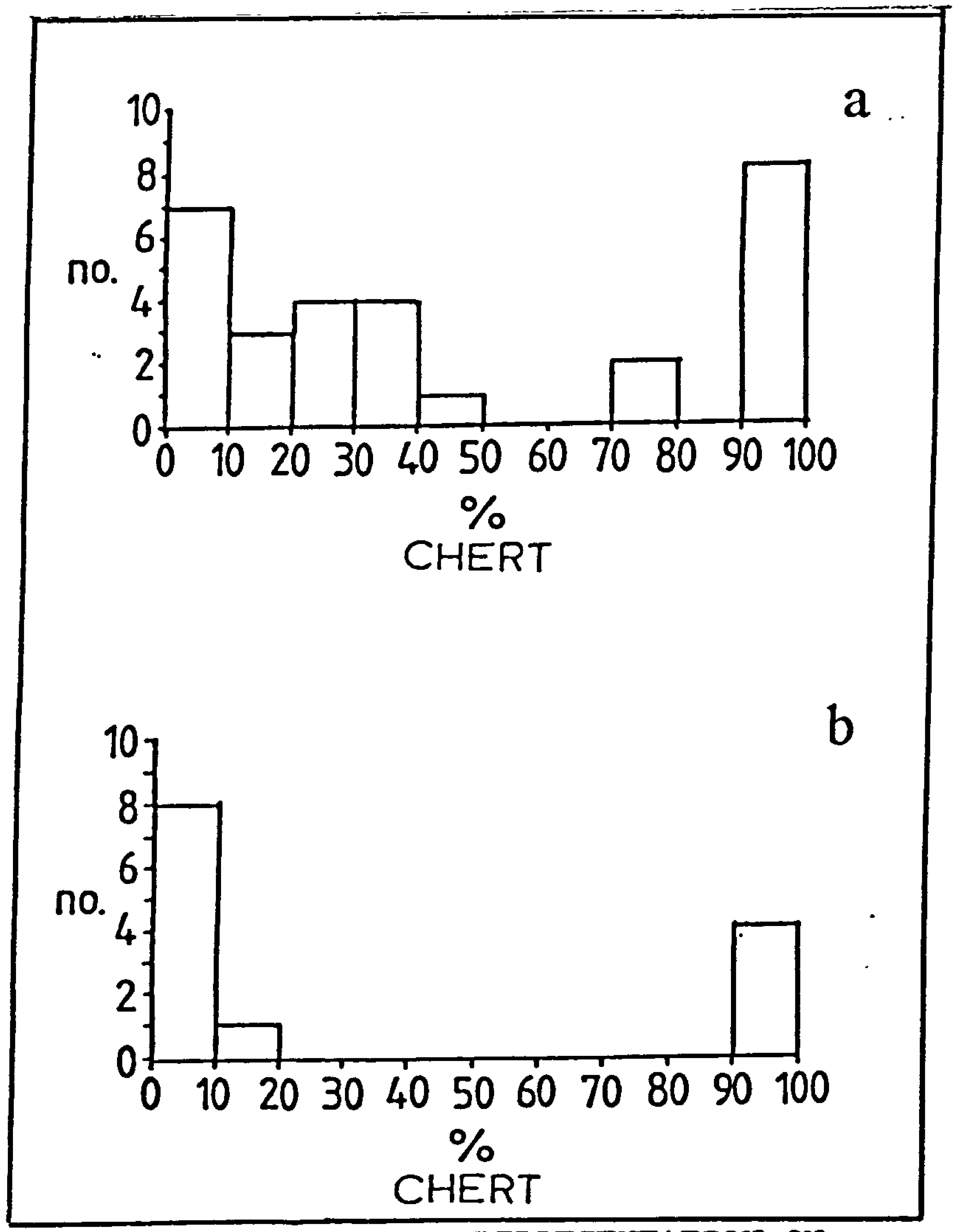
RAW MATERIAL PERCENTAGES FOR PENNINE LATER MESOLITHIC ASSEMBLAGES						
SITE	WHITE FLINT %	BLUE/GREY CHERT %	BLACK CHERT %	BANDED CHERT %	TRANSLUCENT FLINT %	VOLCANIC %
BADGER SLACKS 2	4.84	-	91.49	-	3.67	
BROOMHEAD 5	2.39	4.28	93.03	-	0.29	-
DAN CLOUGH	2.57	1.61	17.17	-	73.65	5.00
DEAN CLOUGH B	-	43.91	5.59	-	50.50	-
DEAN CLOUGH C	-	-	-	-	100.00	-
DRY CLOUGH	-	-	100.00	-	-	-
DUNFORD BRIDGE A	0.71	0.18	-	0.18	98.93	-
DUNFORD BRIDGE B	-	-	-	-	100.00	-
HARRY HUT	6.18	82.73	6.28	-	4.81	-
ICKORNSHAW MOOR	0.87	1.14	4.62	84.07	9.30	-
LOMINOT 4	40.55	37.04	0.46	-	21.95	-
RED RATCHER	-	-	0.95	-	99.05	-
RISHWORTH DRAIN 1	-	95.65	-	-	4.35	-
RISHWORTH DRAIN 2	-	-	100.00	-	-	-
ROCHER MOSS 1	-	-	-	-	100.00	-
ROCHER MOSS SOUTH	68.49	0.86	0.51	-	30.14	-
ROCHER MOSS SOUTH 1	-	-	-	-	100.00	-
WARCOCK 3	-	100.00	-	-	-	-
WARCOCK 4	-	-	-	-	100.00	-
WINDY HILL A	-	-	-	-	100.00	-

table.16

cores of Wolds flint numbered 5 whilst of the remaining 62 translucent flint cores examined at least 7 bore the distinctive sub-cortical yellow stain characteristic of Trent valley gravel flint. In fact, given the similarity in colour and cortex of the large number of translucent flint cores it may well be argued that most of these, including those without the yellow stain, were obtained from the local gravels.

In view of the sourcing difficulties for the translucent flints and many of the Pennine chert varieties it was decided to focus upon the distinctive black Derbyshire chert. This material has been the subject of previous research (Radley 1968) and, as discussed earlier, may be sourced with some confidence to the Monsal Dale (D2) limestone of North Derbyshire. Radley (op. cit.) drew attention to sources of this material in the Wye valley and, less certainly, in the Manifold valley (32). Indeed, the reference to 'chert diggings in Kirkdale below Sheldon' (Radley Archive, Book 2: 83) might indicate that Radley recognized a worked source of material although the precise location is not known.

Employing a series of assemblages, primarily derived from surface collection, Radley (1968: 35) quantified the representation of black Derbyshire chert. One immediately striking feature of his data (no differentiation between Earlier and Later Mesolithic sites was made) is the bipartite division of the percentage representation (fig. 55a) into sites with over 70% and sites with under 50%. Most of the assemblages contain either 40% or less, or more than 90%. If we examine black Derbyshire chert percentages for excavated and well documented surface collections from Later Mesolithic sites in the Pennine region (fig. 55b) it becomes clear that this separation between assemblages is even more pronounced than is apparent from Radley's data. Combining the data from table 16 with the surface collection data from Whitwell GPL 2 and Scarcliffe RLI/RLIA (Hart 1981: 29) we find that of 13 assemblages where black Derbyshire chert is present 9 (69%) have values under 20% whilst the remaining 4 (31%) have values over 90%.



BLACK DERBYSHIRE-REPRESENTATION ON MESOLITHIC SITES : a) Radley 1968, b) Present study.

fig. 55

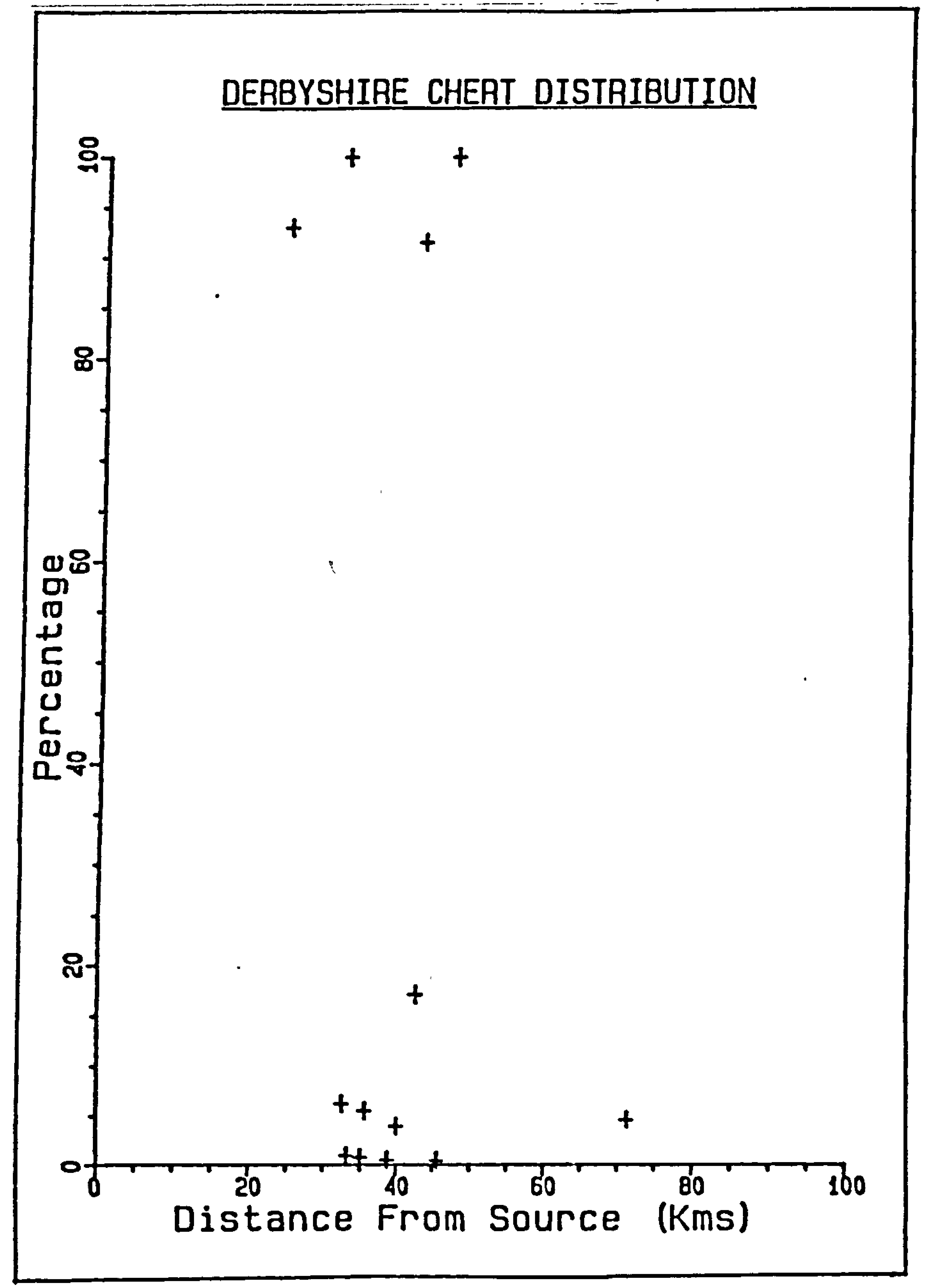


fig.56

a) <u>Raw material representation against distance from source</u>

Clearly, if lithic procurement were cost/distance related we might expect to find reduced percentage contributions with increased distance from source. In order to examine the relationship between distance and percentage contribution the distance has been calculated using the Wye valley source, mentioned by Radley, as the point of procurement. Clearly, we cannot be certain that this particular source was the actual point of procurement but it does serve to illustrate the general area from which this material was probably obtained. As with the Wolds flint analysis straight-line measurements were taken between the source and each site. Using such a measure presents additional problems in that no account of the influence of variable relief upon actual distance on the ground is taken. In general the east-west dissection of the Pennines would serve to increase on-the-ground distances as one moves further north away from the source.

<u>Results</u>

The percentage contribution of black Derbyshire chert does not appear to decrease significantly with increasing distance from source (fig. 56: r = -0.208). Sites whose assemblages are heavily dominated by this chert occur relatively close to the source (i.e. Broomhead V - 93.03%) and at greater distances (i.e. Rishworth Drain 2 - 100%). Similarly, sites with low percentages occur close to (i.e. Harry Hut - 6.28%) and distant from (i.e. Ickomshaw Moor - 4.62%) the source. Consequently, it would seem unlikely that the procurement mechanism was cost/distance constrained and, furthermore, it is not possible to account for the previously mentioned pattern of assemblages with very high and very low percentage contributions in terms of the effects of distance. To this we might add that whilst the patterns of raw material use do change between the Earlier and Later Mesolithic the high percentage contributions of chert at sites such as Badger Slacks 2 (91.49%) and Rishworth Drain 2 (100%), that are approximately 43 and 47 km respectively from the source, suggest that materials are not tied, in their use, to sites close to sources.

b) Perspectives on lithic organization

Whilst it is not possible to provide detailed comparative analyses of black Derbyshire chert use in differing assemblages there are certain specific observations which may prove informative. The site of Badger Slacks 2 (Buckley 1924: 1 - 3) produced an assemblage dominated by black Derbyshire chert concentrated largely within an area of 4 sq. yds. The site, located approximately 43 km from the chert source, contained a series of chert cores (fig. 57) which, at one and the same time, illustrate the differences in core types imposed by the form of raw material and the level of lithic economization in core reduction.

The majority of the cores indicate the use of thin (8 - 12 mm) slabs of chert in their production. The presence of unworked, fine-grained surfaces indicates a seam origin for this material. These cores are consistently worked down just one of the narrow faces. Many of the cores clearly show (fig. 57b - d) a total or virtual absence in core platform preparation with the natural surfaces being used. Furthermore, many of those pieces with non-natural platform surfaces may have had the fracture surface, created in extracting the chert from seams, utilized as platforms. The absence of core platform rejuvenation flakes from the assemblage would appear to confirm the lack of such techniques in the use of these cores.

Some 20 pieces of corrective debitage, including core platform edge removals, were identified and some 461 unretouched flakes counted. The ratio of corrective/flake numbers is 0.043:1 which compares favourably with the lower values obtained in the Earlier Mesolithic debitage analysis (table 14). Significantly, however, the assemblage contained evidence for the production of cores from unmodified pieces of chert on-site. Three unmodified pieces of chert were found to refit with a core fragment (fig. 58a) indicating

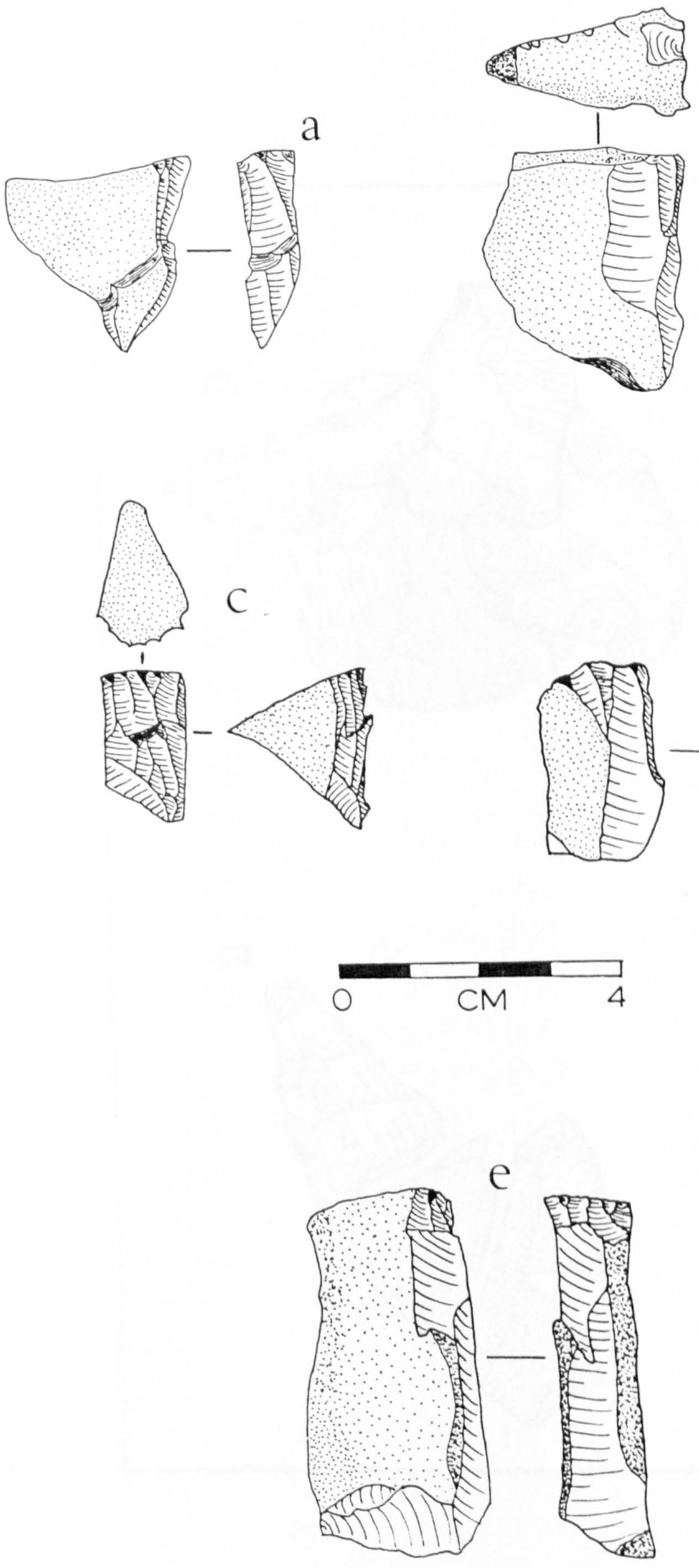


fig. 57

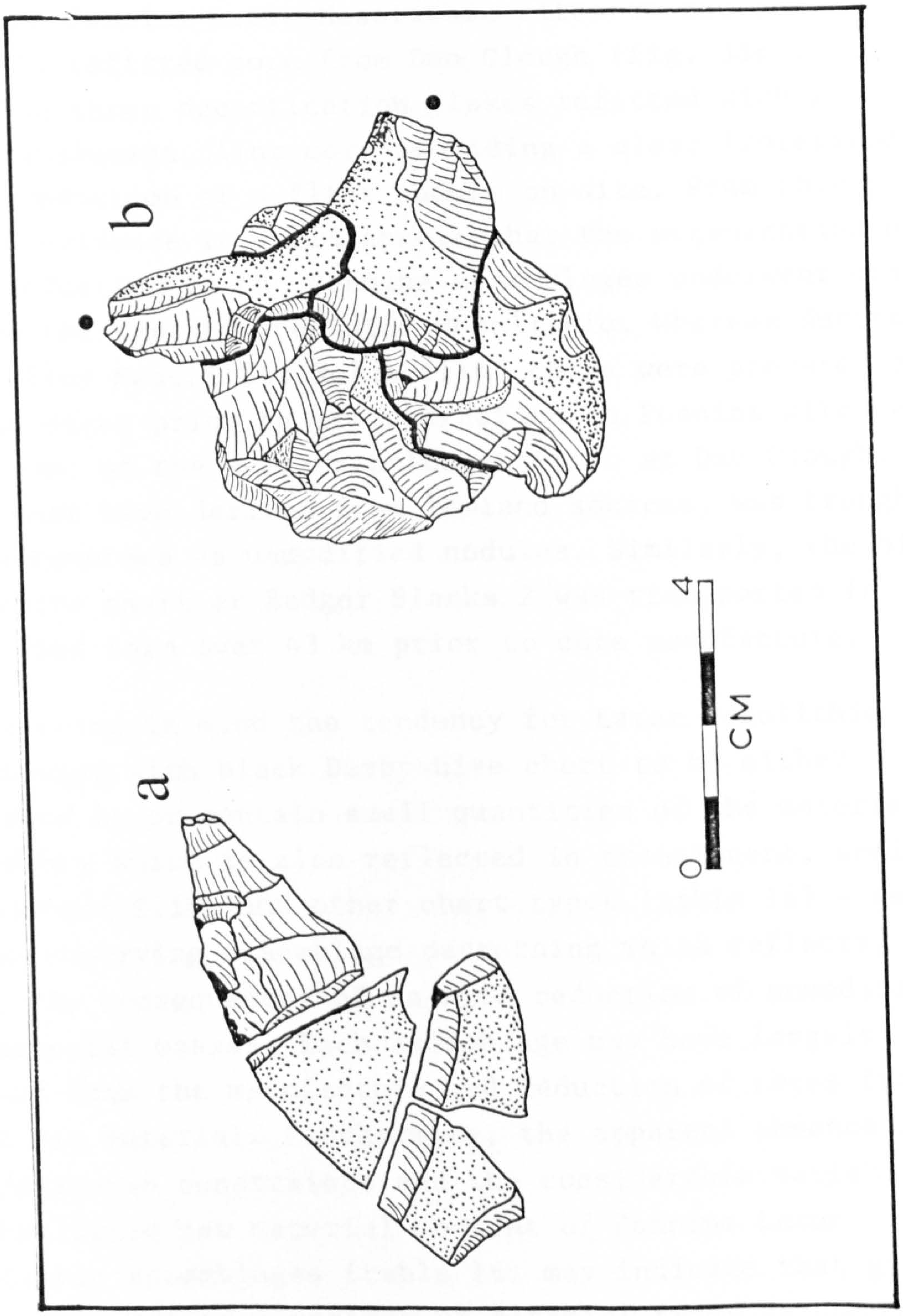


fig.58

the presence of unmodified material and core production. Such evidence, it will be remembered, was absent in the Wolds flint component of Earlier Mesolithic Pennine sites.

To this evidence for core preparation from unmodified masses on Pennine Later Mesolithic sites we can add the partially refitted core from Dan Clough (fig. 58b). In this case three decortication flakes refitted with a semi-translucent flint core providing a clear impression of the reduction of a flint nodule on-site. From this limited evidence it would appear that the organization of core production in the Pennine assemblages underwent changes between the Earlier and Later Mesolithic. Whereas during the Earlier Mesolithic Wolds flint cores were prepared at lowland sites prior to transportation to Pennine sites at least some of the semi-translucent flint at Dan Clough, which must have derived from lowland sources, was brought to the Pennines as unmodified nodules. Similarly, the black Derbyshire chert at Badger Slacks 2 was transported in an unmodified form over 43 km prior to core manufacture.

Bearing in mind the tendency for Later Mesolithic assemblages with black Derbyshire chert to be either dominated by or contain small quantities of the material - a tendency which is also reflected in translucent, semi-translucent flint and other chert types (table 16) - we may be observing assemblage patterning which reflects, in part, the consequences of on-site reduction of unmodified raw material masses. Each assemblage may have largely derived from the manufacture and reduction of cores from fresh raw material. Furthermore, the apparent absence of cost/distance constraints and the considerable variability in the lithic raw material content of Pennine Later Mesolithic assemblages (table 16) may indicate that groups were transporting a variety of material types as unmodified masses over considerable distances prior to their reduction. It would be difficult to envisage the input of black Derbyshire chert at sites such as Badger Slacks 2 and Rishworth Drain 2 as being the result of task-groups moving out from these sites to Derbyshire and returning with embedded supplies. Such a situation would be difficult to explain in terms of subsistence and mobility schedules.

How might we understand this apparent shift in the organization and scheduling of core preparation? Under which circumstances would a strategy of accumulating and transporting nodules of raw material over extended periods of time and/or distance make sense? In attempting to answer these questions we may return to some of the implications for Later Mesolithic subsistence, settlement and technology outlined in previous chapters. It has been argued that the principal contrast between food procurement schedules in the Earlier and Later Mesolithic lay in the degree to which groups could accurately anticipate the spatial and temporal availability of game. In particular, the shift amongst target resources away from migratory to non-migratory strategies promoted the adoption of subsistence and settlement strategies during the Later Mesolithic suited to the exploitation of dispersed animal populations.

The resulting increase of residential mobility with reduced residential group sizes and lower levels of spatial redundancy was accompanied by shifts in technological structure towards weapons capable of functioning and of being maintained at very short notice. In other words, the technology accommodated the need for hunting efficiency in the context of a system where technological and subsistence schedules could not be segregated. Under these circumstances, and given the decrease in spatial redundancy, it might make sense for groups to secure the basis for lithic production at any given moment. Without the secure knowledge that inputs of embedded lithic supplies would coincide with technological demands it would be appropriate for groups to perpetually carry a supply of raw materials ready for use at any given moment. Consequently, the presence of complete reduction sequences, including initial core manufacture, on Later Mesolithic sites may represent an organizational response to the unpredictability of the timing and location of manufacturing and maintenance activity.

Within such a model the shift in the technological/ mechanical demands of flake/blade production away from long-narrow blades towards less regular, squat blades/ flakes could be seen as an adjustment to the variability of raw materials encountered during the course of frequent residential moves undertaken across the whole or most of the landscape. In other words, the design limitation applied to microliths may, as a technological accommodation to variable raw materials, apply to the whole organization of lithic technology.

With regards to subsistence schedules one of the major implications of this view of Later Mesolithic strategies is that, unlike the Earlier Mesolithic, hunting strategies remained generalist and encounter-based throughout the year. Consequently, Later Mesolithic assemblages should reveal a consistent pattern of the replacement/maintenance of existing projectiles as opposed to evidence for 'gearing-up'. Consideration of the relative numbers of microliths and micro-burins on Later Mesolithic sites (fig. 59) reveals, however, that at two sites, Blubberhouses Moor (Davies 1963) and Badger Slacks 2 (Buckley 1924), numbers of micro-burins are greater than numbers of microliths. At this point it must be acknowledged that, in keeping with the majority of Later Mesolithic sites, the absolute numbers of microliths and micro-burins are very small. Percentage comparisons based upon such small sample sizes must be treated with extreme caution. However, if we as archaeologists are to include the full range of sites available as opposed to concentrating upon prolific sites we must, at some level, be prepared to handle such data.

At Blubberhouses Moor 5 microliths and 8 micro-burins were recovered. However, the micro-burin count included mis-hits (Davies op. cit.: 63), and it is evident from the site report that,

> 'Of the micro-burins, four have been made on butt-ends, one, on a tip-end and three are mis-hits.'
>
> (Davies op. cit.: 64).

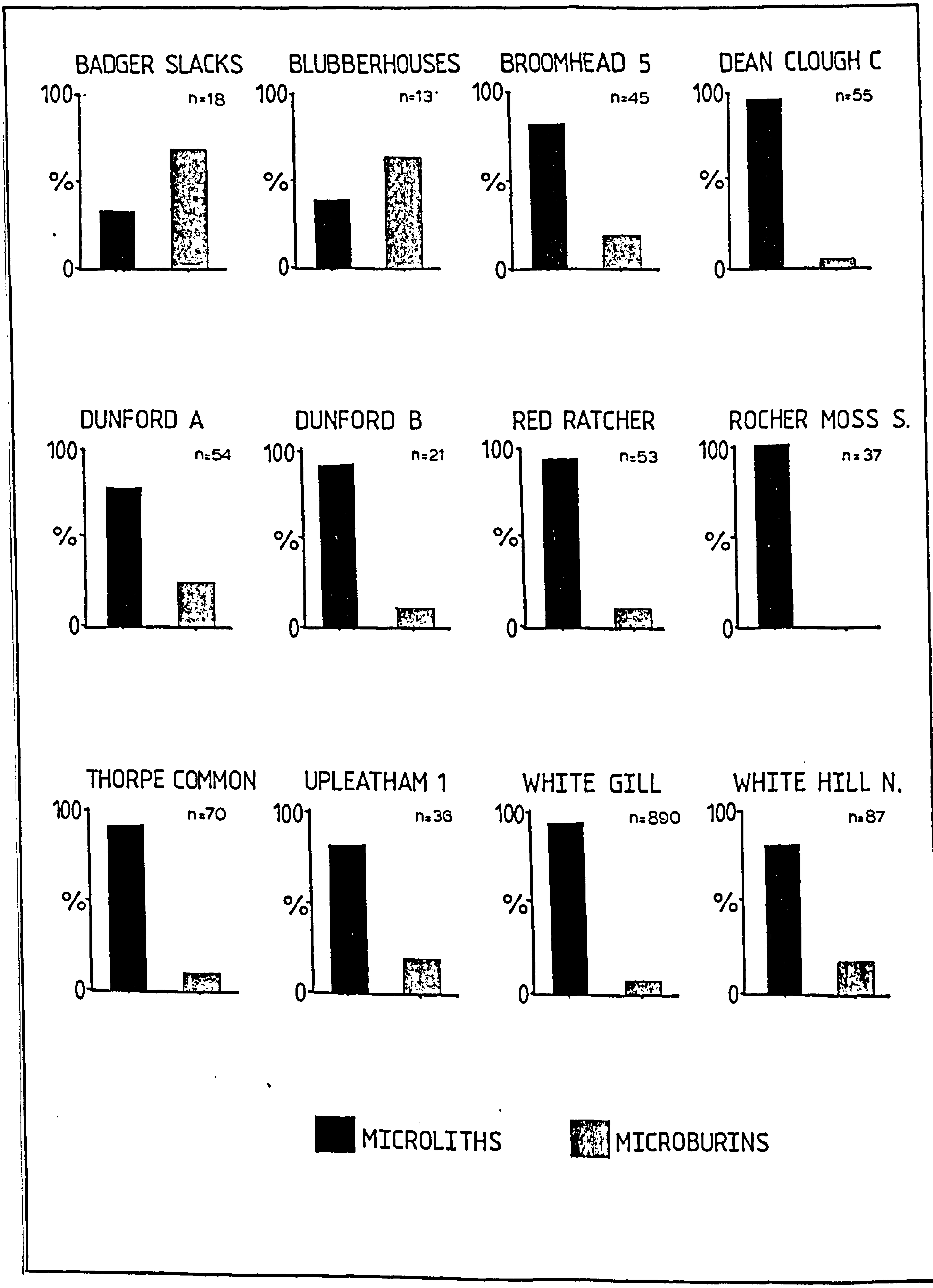

BADGER SLACKS
n=18
BLUBBERHOUSES
n=13
BROOMHEAD 5
n=45
DEAN CLOUGH C
n=55
DUNFORD A
n=54
DUNFORD B
n=21
RED RATCHER
n=53
ROCHER MOSS S.
n=37
THORPE COMMON
n=70
UPLEATHAM 1
n=36
WHITE GILL
n=890
WHITE HILL N.
n=87
100
%
0
MICROLITHS
MICROBURINS

fig. 59

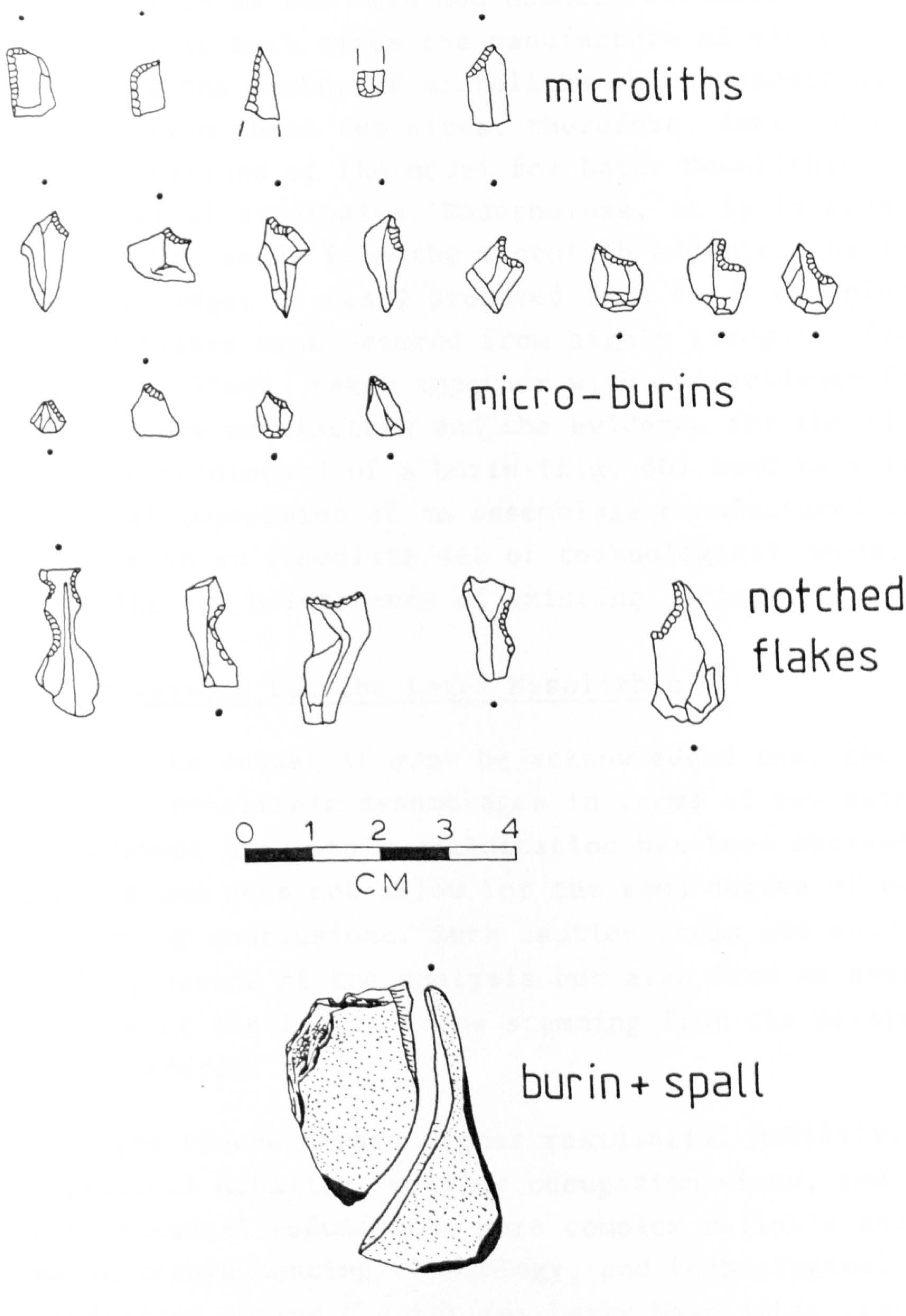

microliths
micro-burins
notched
flakes
0 1 2 3 4
CM
burin + spall

fig. 60

Similarly, at Badger Slacks 2, 6 microliths and 12 micro-burins were recovered, but of the latter 6 were bulbar and 6 were distal pieces. In view of the need to assess microlith manufacture rates using a count of bulbar pieces as the 'minimum number' estimate it becomes clear that at both sites the manufacture of microliths does not exceed the number of microliths being deposited. The evidence from these two sites, therefore, does not contradict the expectations of the model for Later Mesolithic technological strategies. Nonetheless, it is interesting to note that aside from the microlith and micro-burin evidence Badger Slacks 2 produced five clear examples of notched flakes manufactured from highly irregular flakes (fig. 60). These, taken together with the evidence for on-site core manufacture and the evidence for the situational manufacture/discard of a burin (fig. 60) tend to reinforce a general impression of an assemblage manufactured in response to an immediate set of technological needs, including the maintenance of existing projectiles.

c) Conclusions for the Later Mesolithic

At the outset it must be acknowledged that the analysis of Later Mesolithic assemblages in terms of raw material procurement and lithic organization has been extremely limited and does not allow for the same degree of conviction in drawing conclusions. Such caution stems not only from the limited nature of the analysis but also from an awareness of some of the implications stemming from the perspectives being offered.

The trends toward higher residential mobility, reduced logistical mobility, smaller occupation sites, reduced environmental redundancy, more complex reliable and maintainable hunting technology, and technological design limitation during the Earlier-Later Mesolithic transition may be understood within a model where subsistence schedules adjusted to less seasonally structured, more evenly distributed resources. Similarly, the loss of barbed point technology during the Later Mesolithic can be understood partly as the response to demands for reliable and maintainable hunting equipment and partly as the result of the loss of large, predictable incidental inputs of antler during autumnal strategies.

Yet under this model for Later Mesolithic behaviour the breakdown in the capacity to employ extensive logistical strategies and the implied shift towards strategies where smaller residential groups covered the greater part of the regional landscape in their movements suggests that the Later Mesolithic may have witnessed considerable local or regional diversity in subsistence strategies. In particular, the problems of coping with dispersed resource exploitation within an environment where primary productivity was still seasonally structured must have given rise to a variety of risk-reduction strategies. The evidence for deliberate clearance, fodder collection etc. may be seen as one potential response for reducing the unpredictability of hunting. By the same token, the exploitation of shellfish during winter may be regarded as one strategy for introducing low-risk resources into the context of the high-risk strategy of actively hunting during winter.

The degree to which groups may have adopted risk-reduction strategies in order to counterbalance the uncertainty of encounter hunting will have varied according to local environmental conditions. Some regions may have offered conditions for mixed risk-reduction strategies, whilst others may have proved less amenable. Whatever one concludes it is readily apparent that Later Mesolithic strategies may have exhibited considerable regional diversity. We can go some way in confirming this view by considering the evidence from southern England for the procurement of Portland chert.

Portland chert: contrasting procurement strategies

As previously discussed, the Mesolithic saw the appearance of a distinctive chert derived from the limestone of Portland, Dorset, over much of southern England. Whilst it is possible that limited supplies of this material were available from inland sources or coastal beach deposits there are reasons for suggesting the Isle of Portland as the principal source. Not least of these is the presence, on the Isle of Portland, of two known Mesolithic sites (fig. 61) - Culver Well (Palmer 1976, 1983) and Site 1 (Palmer 1969, 1971) - whose assemblages are dominated by Portland chert. As discussed previously, there are reasons for suggesting - on locational, economic and industrial grounds - that these sites, and particularly Culver Well, were occupied primarily for the procurement and reduction of Portland chert.

The possibility that Culver Well, demonstrably Later Mesolithic in date, was occupied primarily for lithic access immediately indicates a contrast with both Earlier Mesolithic and northern Later Mesolithic raw material procurement systems. The absence of raw material source-based sites during the Earlier Mesolithic and in the Later Mesolithic of northern England suggests that Culver Well was occupied as part of a system where lithic procurement and settlement strategies differed in at least certain aspects. From the brief discussion of interpretations of the Portland chert distribution in chapter 4 it was recognized that various authors have suggested that this material participated in exchange/barter transactions during the Mesolithic. Beyond noting the presence of small quantities of this material in sites distant from Portland, however, little in the way of systematic analysis has been undertaken.

Purely as a preliminary step in advancing our understanding of the nature of the Portland chert distribution data from published sources where this material has occurred in Mesolithic assemblages has been used in plotting the overall percentage contribution (table 17) against the straight-line distance from the northernmost cliffs of Portland where some of the most accessible deposits of Portland chert occur. The resulting distribution (fig. 62a) shows a pronounced fall-off with increasing distance from source up to approximately 40 km from

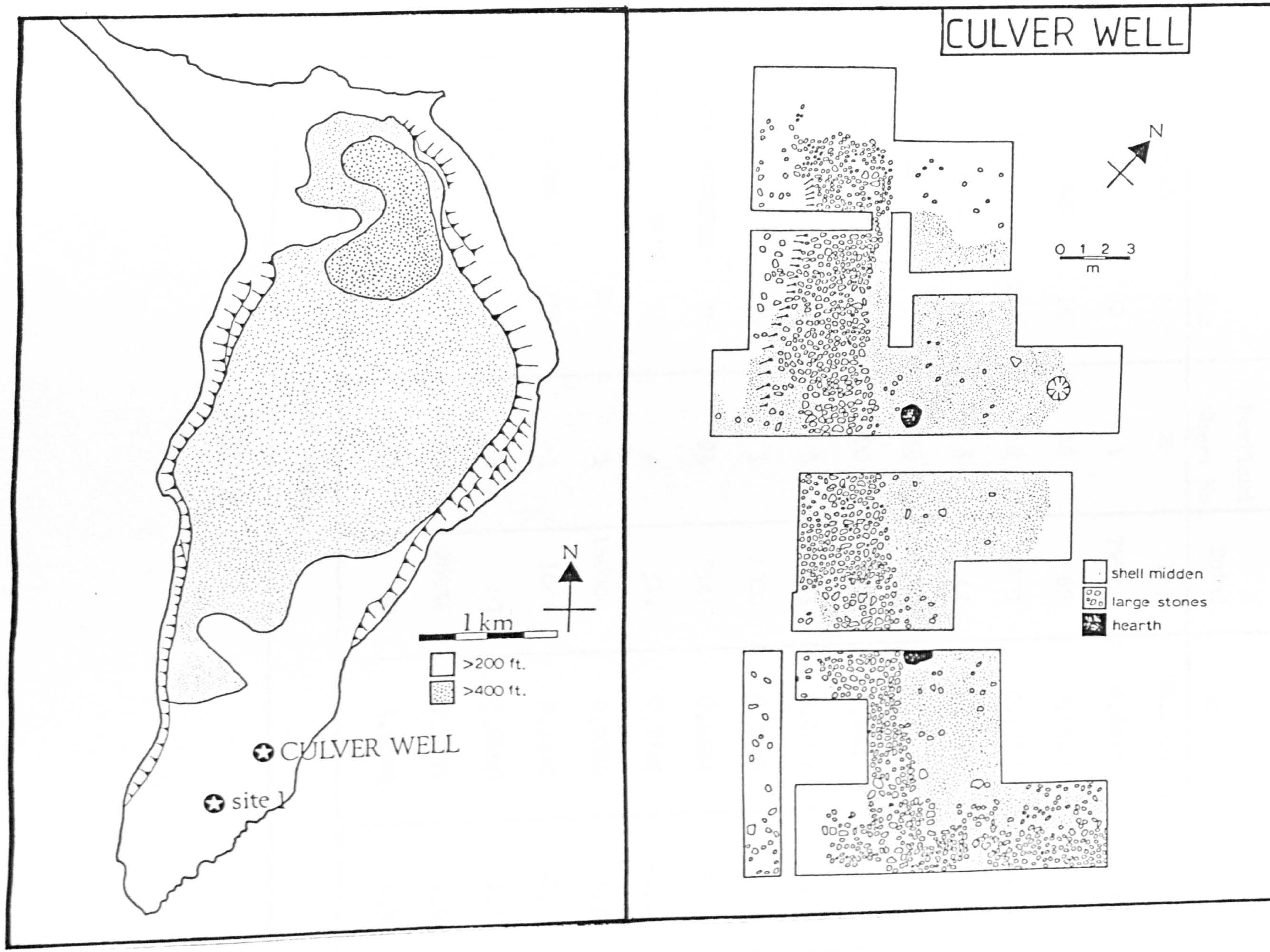

N
1 km
>200 ft.
>400 ft.
CULVER WELL
site 1
CULVER WELL
N
0 1 2 3
m
shell midden
large stones
hearth

fig.61

REPRESENTATION OF PORTLAND CHERT AND DISTANCE FROM SOURCE					
Site	Kms	Portland Chert No.	Total	%	Log. %
BLASHENWELL	33	20	143	28.6000	1.46
BROOMHILL	90	1	79571	0.0013	-2.90
CHALDON DOWN	18	12	62	19.3548	1.29
CHERHILL	114	2	1929	0.1037	-0.98
CHURCH KNOWLE	42	3	42	7.1428	0.85
CULVER WELL*	1	13536	16920	80.0000	1.90
FLEET SITES	10	1500	2066	72.6041	1.86
FARNHAM	136	3	40683	0.0074	-2.13
FRENSHAM	136	1	1000	0.1000	-1.00
IWERNE MINSTER	45	23	3547	0.6484	-0.19
MOTHER SILLER'S	56	4	514	0.7782	-0.11
OAKHANGER	127	1	186000	0.0005	-3.30
PEACEHAVEN	183	2	1087	0.1840	-0.74
SHORWELL	90	3	60	5.6000	0.70
SITE ONE	1	22373	26956	82.9971	1.92
ULWELL	40	1	30	3.3000	0.52

* = estimated values

table.17

Portland whereupon the fall-off appears to decrease in rate. There is a clear visual similarity between the fall-off pattern for Portland chert and the modelled fall-off for exponential distance-decay (fig. 6). Confirmation of the similarity is provided by the transformation of percentages into logarithms of percentage values and plotting these against distance from source (fig. 62b). The resulting correlation ($r = 0.773 : p < .001$) confirms the correspondence between the expected and observed fall-off pattern.

From the fall-off evidence, therefore, it might be claimed that the distribution of this material conforms with the mechanisms of procurement discussed by Renfrew (1977) in connection with exponential distance-decay patterns. The down-the-line exchange mechanism considered by Renfrew (see chapter 2) would clearly prove attractive for those who have suggested that Portland chert participated in an exchange network.

However, several points concerning the data-base need to be stressed. First, although the majority of the 16 assemblages are Later Mesolithic or contain Later Mesolithic material the site of Farnham, for example, belongs to the Wealden or 'Horsham' tradition, whilst Oakhanger is Earlier Mesolithic in date. Furthermore, the prolific site of Iwerne Minster is a multi-period assemblage including both Earlier and Later Mesolithic material.

Secondly, many of the assemblages from beyond the immediate area around Portland are very small (i.e. Church Knowle, Ulwell, Shorwell and Chaldon Down), and it is also evident (table 17) that the quantity of Portland chert on many sites is also very small. For assemblages with evidence for re-occupation, such as Oakhanger, the percentage of Portland chert, ideally, should be calculated for individual occupation levels or assemblages.

These problems aside, however, the observed fall-off is sufficiently ambiguous as to suggest at least one

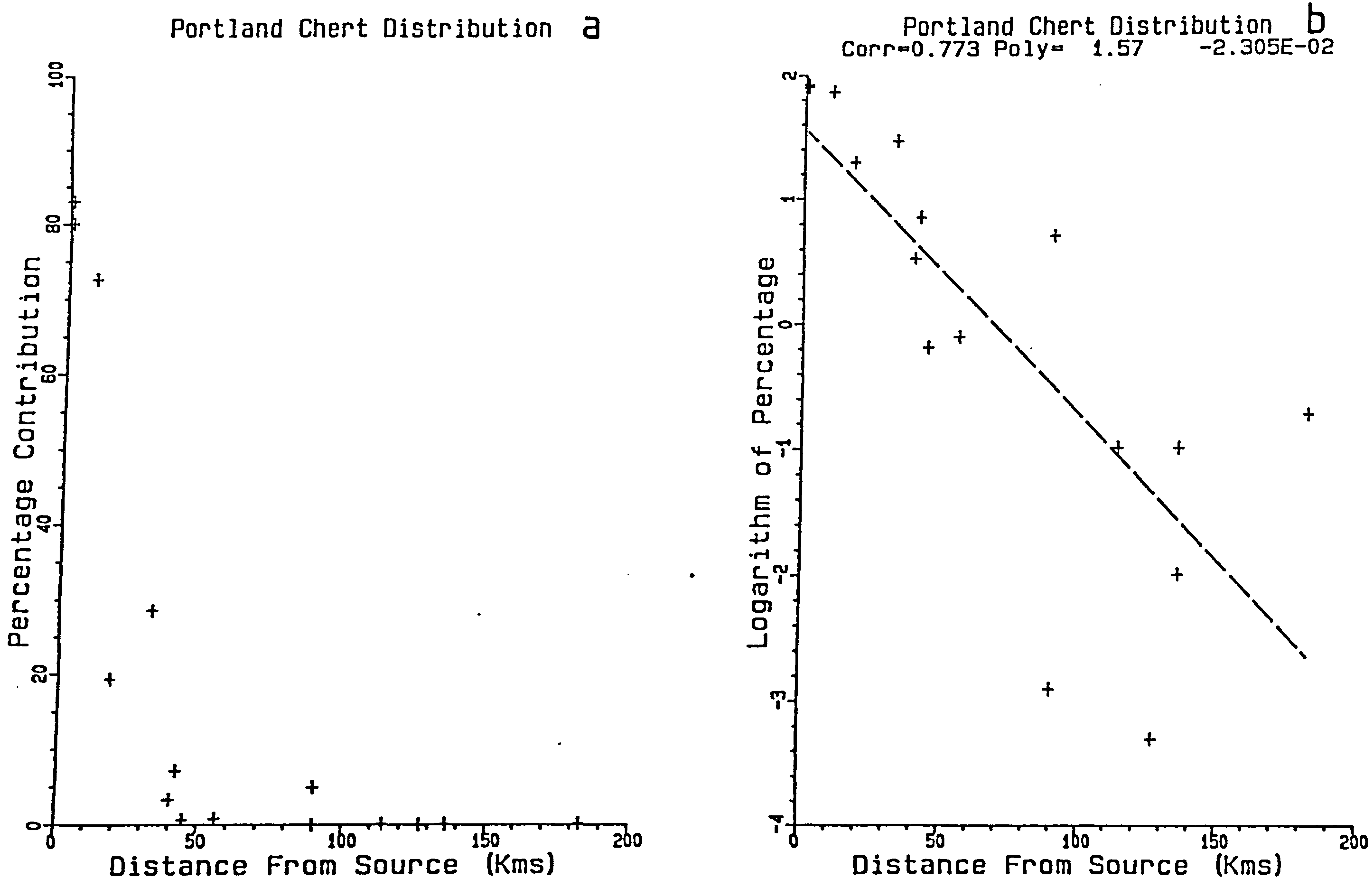

Portland Chert Distribution a
Percentage Contribution
Distance From Source (Kms)
0
20
40
60
80
100
50
150
200
Portland Chert Distribution b
Corr=0.773 Poly= 1.57 -2.305E-02
Logarithm of Percentage
-4
-3
-2
-1
0
1
2

fig.62

alternative explanation for the pattern. The steep fall-off over the first 40 km and the less dramatic fall-off thereafter might also suggest the operation of two distinct mechanisms. Within 40 km of Portland material may have been procured by a direct-access mechanism or through indirect supply-zone procurement, producing a linear distance-decay, whilst beyond 40 km the material passed into another mechanism of 'supply' producing a linear distance-decay with a different gradient. Only through a detailed analysis of contrasts in the lithic debitage/tool depositional evidence could these competing models - exponential distance/decay or dual mechanisms - be adequately examined.

What is evident, however, is that the Portland chert distribution differs in character from the observed patterns for Wolds flint and black Derbyshire chert in northern England. The recognition of a distance constrained pattern generated, principally, in Later Mesolithic contexts and the appearance of, for want of a better term, 'quarry-based' sites during the Later Mesolithic in southern England strongly suggests that the period saw a diverse set of lithic procurement strategies in different regions. Given the importance of variations in the scheduling of technological and subsistence/mobility behaviour in understanding the nature of hunter-gatherer strategies the observed diversity in lithic procurement organization during the Later Mesolithic would support the view that the Later Mesolithic witnessed a diversification of strategies according to regional variations in subsistence options. Such a conclusion, whilst being very general in nature, would accord with the overall view of Later Mesolithic adaptation developed in this thesis and further emphasize the contrast between Earlier and Later Mesolithic adaptations on the British mainland.

Chapter Six:

Conclusions and implications

1) Summary of the theoretical background

Archaeological research into prehistoric hunter-gatherers has traditionally relied upon our ability to make sense of patterns observed within and between archaeological assemblages. In this task studies of contemporary hunter-gatherers have a long established relationship with archaeological interpretation. The intimate, yet often implicit role played by ethnographically derived perspectives in our views of the past has served to shape the ways in which archaeologists have set about their allotted tasks. It is, therefore, not surprising that as research into contemporary groups has developed and modified our understanding of hunter-gatherer behaviour then, so too, archaeologists have viewed the prehistoric record within a new light.

Despite the relationship between studies of contemporary and prehistoric hunter-gatherers, however, the years have witnessed the establishment of a dichotomy in this relationship which has been difficult to resolve. On the one hand, general perspectives on the nature or character of hunter-gatherer adaptations have undergone pronounced changes largely through the rejection of traditionally held assumptions as a result of detailed study and observation of contemporary behaviour. The formulation of fresh general perspectives has, in turn, found amongst archaeologists an audience ready and willing to adopt the new creed of understanding.

On the other hand, the interpretative changes so readily undertaken by archaeologists have not, for the most part, been matched by changes in the analytical methodology or philosophy of prehistoric research. The emphasis upon stylistic/cultural correlation in the study of archaeological data has, since the work of Childe, dominated archaeological approaches to the past. It is my view that this conservatism has arisen partly from the traditional concern with providing chronological/sequential order in the archaeological record and partly from the dichotomous goals of ethnographic and prehistoric research. Whilst ethnography focussed upon the description of behaviour with little concern for the material correlates of behaviour archaeologists found ethnographies to be rich in behavioural and poor in archaeologically referable information.

Consequently, perspectives on behaviour - such as the dietary importance of plant-foods in hunter-gatherer economy - have changed, due to the work of ethnographers, and been absorbed into prehistoric discussion. On the other hand, archaeologists have found great difficulty in relating these new behavioural perspectives to an archaeological record whose content and patterning remained dominated by classes of evidence for which few ethnographies provided useful information. Even with the growth of awareness concerning the functional variability of hunter-gatherer tool assemblages the contrasting value of ethnographic research to archaeologists ensured that the stylistic/cultural paradigm would remain at the heart of prehistoric research.

The growth of ethnoarchaeological research, largely as a response to the dissatisfaction with the dichotomy in ethnographic and prehistoric research, initiated the erosion of the boundaries between the two disciplines. Even so, as long as such research remained particularistic, that is to say confined within the study of individual communities, and divorced from general theory seeking to account for the diversity of behaviour archaeologists continued to employ studies of contemporary societies as sources of possible analogies. Whilst analogy, both at a behavioural and artefactual level, is not, of itself, detrimental or even avoidable it cannot achieve an understanding of the diversity of contemporary or prehistoric adaptations.

For these reasons the development of general theory seeking to relate behavioural diversity to adaptational principles or goals combined with middle-range theory where archaeological formation processes are modelled within, in part, behavioural contexts provides a major departure from the traditional framework within which ethnography contributed to prehistoric research.

2) Conclusions for lithic organization and structure

This thesis has attempted to integrate the general principles of cost and risk limitation within a theory of hunter-gatherer subsistence, settlement and technology in order to provide a framework for understanding the adaptive roles of technological organization and structure. In place of viewing technology as an isolated sub-system it has been argued that the organization of lithic procurement, manufacture, maintenance and discard as well as the structural dimensions of assemblage composition, diversity and complexity may be viewed as adaptive responses to time (risk) and/or cost considerations within subsistence schedules and in the performance of subsistence tasks.

It has been argued that variations in levels of risk and cost associated with subsistence may be related to the settlement, mobility and technological strategies of hunter-gatherers. In particular, the organizational and structural dimensions of lithic technology, mediated by the specific spatial and temporal characteristics of target resources, have been discussed as being adaptive to the relative benefits of limiting subsistence costs and/or risks. Lithic procurement, manufacturing and maintenance may be viewed as being particularly responsive to the risk/cost demands arising from subsistence schedules. Scheduling, by its very nature, involves the allocation of time, itself a finite resource, in the performance of tasks. Where the subsistence strategy, because of the associated risks, demands efficiency in the use of time subsistence and technological time allocations are, where possible, segregated. The avoidance of conflicting subsistence and technological time allocations maximizes subsistence time and minimizes risks. Where subsistence strategies are constrained by energy, as opposed to time, there are fewer selective pressures and less adaptive benefits in segregating subsistence and technological schedules. In other words, where food procurement is cost constrained there is less to be gained from seeking to separate subsistence and technological activity.

The structural dimensions of assemblage composition, diversity and complexity have been argued to be particularly responsive to the demands for efficiency in the performance of subsistence tasks. Where risks are great and time is limited the benefits arising from the use of task-specific, complex tools achieve their most significant role. Efficiency in task performance and increased chances of success maximizes subsistence time and minimizes risk: where subsistence tasks are cost constrained the use of more generalized, less complex tools may prove more adaptive, and the use of task-specific, complex tools may even prove maladaptive.

It has also emerged that under conditions where subsistence risks are high but where subsistence and technological schedules cannot be effectively segregated design-limitation strategies in both the organization and structure of technology may be employed. Organizationally, design-limitation strategies enable the production and maintenance of assemblages to be undertaken within unpredictable, non-scheduled time allocations. To this end the structure of food procurement technology, and weapons in particular, may be designed to provide high levels of maintainability and reliability. The manufacture of complex, composite weapons with built-in component redundancy serves to ensure that such tools may be available for use at short notice whilst enabling their maintenance to be undertaken when and where the time for such activity occurs.

3) Conclusions for the Mesolithic of mainland Britain

The analysis of the Mesolithic of mainland Britain fell broadly into two parts: an assessment of our current understanding of the environment, chronology, economy, settlement and technology of the period, and a case study examining the regional lithic data-base of northern England. Under the former, the broad chronological/typological division of the Mesolithic into an Earlier and Later phase was found to correspond with changing patterns of settlement, economy and technology against a background of significant environmental changes. Current classificatory frameworks for the recognition of assemblage types were found to be inadequate as they fail to allow for the implications of the changing microlithic tool design, and specifically the increase in complexity, noted for the Earlier to Later Mesolithic transition. Indeed, doubts were raised concerning the traditional interpretation of microliths as tools, on the same basis as other retouched forms, and it is suggested that microliths, particularly during the Later Mesolithic, should be explicitly handled as tool-components. The need to distinguish between retouched lithic forms which were subject to reductive maintenance/resharpening and those whose replacement formed the basis for tool maintenance carries implications for inter-assemblage analysis beyond the Mesolithic.

Within the context of the changing environmental resource background the available economic evidence, particularly for the Earlier Mesolithic, was found to conflict with established models of Mesolithic subsistence. Both in its own terms and with respect to the goals of risk/cost limitation the Clark (1972) model of upland-summer, lowland-winter mobility centred upon the specialized exploitation of Red deer was found to be inadequate. It was argued that faunal evidence indicated a generalized hunting strategy with selective inputs into lowland sites from specialized Red deer exploitation undertaken in upland and upland valley locations. In the light of environmental and resource-behaviour considerations an alternative model of Earlier Mesolithic subsistence and settlement was proposed.

Under this revised model it was envisaged that Earlier Mesolithic groups engaged in the generalized exploitation of lowland resources during spring and summer. Autumn saw the focus of activity shift to upland and upland valley locations primarily for the execution of specialized intercept hunting of Red deer. Winter was spent at lowland residential sites with subsistence being based upon cached meat supplies derived from the autumnal strategy. Such a model, it was argued, was more sensitive to available faunal evidence and more appropriate, within the environmental context, to the goals of risk minimization.

The Later Mesolithic, in contrast, saw major changes towards residential versus logistical mobility with subsistence strategies being generalized in nature. These changes were linked to the impact of the rapid climatic amelioration upon vegetation and resource behaviour between c. 7000 and 6000 b.c.. One of the major subsistence contrasts between the Earlier and Later Mesolithic was argued to be the loss of conditions suitable for the use of an autumnal intercept hunting strategy. Denied the opportunity for over-wintering on cached meat supplies Later Mesolithic groups adopted alternative strategies for the winter period. For some, as shown from Morton Tayport B (Deith 1983) the exploitation of shellfish provided a low-risk, low-return (high-cost) option for over-wintering. For other groups it may have been possible to store plant-foods as part of the over-wintering strategy, although evidence for such behaviour is not, as yet, clearly recognizable in the archaeological record. In many cases, therefore, the Later Mesolithic may have witnessed groups remaining active in hunting during the winter. Such a strategy implies high levels of risk associated with subsistence for at least part of the year.

The evidence for the adoption of a variety of game management strategies in the form of selective forest clearance and fodder collection may represent indications of risk limitation behaviour in Later Mesolithic subsistence hunting. Such strategies, whilst increasing the efficiency in hunting by reducing time spent in locating and pursuing game, may not have offered the necessary opportunities for accumulating surplus meat for the winter period. The marked increase in the complexity and, less clearly, diversity of hunting technology may be, in part, seen as structural responses to the need for efficiency in game procurement.

The case study from northern England provided clear support for the revised model of Earlier Mesolithic subsistence and settlement. Having considered a variety of possible lithic procurement mechanisms in connection with the distribution of Wolds flint the developed embedded model was found to provide the most appropriate account. Under this model the input of embedded lithic supplies varied in regularity and quantity with changes in the nature of the subsistence strategies. Under the revised Earlier Mesolithic model it was anticipated that the spring and summer were spent in lowland encounter hunting. During this period the input of embedded lithic supplies would be at its most regular producing large quantities of material from sources located in the areas of such encounter-based mobility. In contrast, the autumnal intercept period would provide few opportunities, due to the efficiency-stressed nature of the activity, for embedded lithic inputs.

The observed organizational evidence for lowland core preparation and the transportation of preformed cores to upland valley residences made sense in terms of an embedded system designed to avoid conflicts in technological and subsistence schedules during the time-stressed autumnal intercept strategy. The evidence for gearing-up of microlithic hunting technology in the form of blade morphology and micro-burin - microlith ratios at Deepcar confirmed the anticipated pattern of anticipatory projectile manufacture in advance of an autumnal intercept strategy. Taken together with the dominance of Wolds flint in Earlier Mesolithic Pennine assemblages it was concluded that the revised model appeared to provide archaeological expectations which conformed with the observed patterning. The resulting model of Earlier Mesolithic subsistence, settlement and technology (fig. 52) reveals the balanced incidental input of lithic raw materials during spring and summer, and of antler following the autumnal strategy thereby integrating the microlithic and barbed-point hunting technologies within one adaptive system.

In terms of the Later Mesolithic the study of assemblages in northern England revealed that whilst raw material use patterning differed from the Earlier Mesolithic and saw the extensive usage of a variety of flints and cherts the procurement mechanism, once again, appeared to be unrelated to distance/cost considerations. Certain raw materials, such as black Derbyshire chert, appeared as a dominant material on sites some considerable distance from the source area. However, unlike the anticipatorily organized reduction system noted for the Earlier Mesolithic, the Later Mesolithic appears to have seen a system where raw materials were transported in a largely unmodified form over considerable distances prior to the manufacture of cores. This organizational change in lithic reduction was linked to the absence of a segregation in technological and subsistence schedules. The primary concern appears to have been connected with providing the adequate supply of raw materials in a context where manufacturing and maintenance activities could not be temporally anticipated.

The production of tools, and especially microliths, from less regular pieces was seen as part of the design-limitation strategy whereby inputs from a variety of raw material sources of varied mechanical properties could serve the same technological goals. Given the anticipated shift towards reduced environmental redundancy in settlement patterns this ability to manufacture/maintain a technology with varied materials would represent a significant accommodation or response. In this way Later Mesolithic groups secured the means of technological production within the context of a system where embedded lithic inputs from a variety of sources served in non-scheduled manufacturing and maintenance activities. The design of microlithic components capable of manufacture from irregular blades/flakes represented one further dimension to this strategy.

As previously noted, the complexity and degree of standardization in component design for Later Mesolithic projectiles suggested a need for reliable and maintainable equipment. The loss of distinct schedules for subsistence and technology in the context of a time-stressed economy demanded a technological response which ensured the availability of functioning weapons at any given time. From the available data on micro-burin - microlith replacement/manufacture it appears that, to date, no examples of sites with evidence for gearing-up of hunting technology exist, providing some confirmation of the suggested emphasis upon encounter strategies during the Later Mesolithic.

The loss of an autumnal intercept strategy based upon Red deer hunting was seen to carry further explanatory implications for technology. The demise of barbed points following the Earlier-Later Mesolithic transition may, in part, reflect the impact of the non-availability of reliable incidental inputs of Red deer antler. This change in raw material procurement opportunity may have further encouraged the abandonment of antler projectile technology in favour of a lithic based option. However, the complexity of Later Mesolithic projectiles does suggest that the need for reliable and maintainable projectiles arose as a result of time-stress in a subsistence system where technological activity could not be separately scheduled.

Finally, attention was drawn to evidence for cost/ distance constrained lithic procurement systems in southern England. The possibility of recognizing, in the contrast between black Derbyshire chert and Portland chert distributional patterning, the emergence of regional variability in lithic procurement systems during the Later Mesolithic raises certain questions concerning the mobility strategies and subsistence organization of populations in differing areas. Certainly, one consequence of the shift towards greater residential mobility in the context of an environment still exhibiting seasonality in primary productivity might be the adoption of a variety of risk-reducing strategies dependent upon the localized opportunities for specific options. In some areas, for example, it may have proven possible to combine winter shellfish collection with spring/summer hunting connected with areas of anthropogenically promoted clearance thereby reducing subsistence risks over much of the year. In other regions the exploitation of anadramous fish resources may have served similar adaptational goals.

In this light, it is interesting to recall that the Later Mesolithic witnessed a growing regionalization in microlithic styles. To what extent such evidence may equate with a diversification of economic schedules, or even the development of regionalized systems of socio-economic interaction is, as yet, a matter of some speculation. What is clear is that the Later Mesolithic presents a series of marked contrasts with the Earlier Mesolithic deserving of increased research interest.

4) Implications

This thesis has concentrated upon the adaptive role of lithic organization and structure amongst hunter-gatherers. Attention has been drawn to the importance of time scheduling within subsistence and technological activities in the development of an understanding of hunter-gatherer adaptations and how the limitation of costs and risks relates to such scheduling behaviour. In seeking to develop and apply methodologies for examining the nature of scheduling and cost/risk limitation strategies to the Mesolithic it has proven necessary to focus upon certain dimensions of lithic organization and structure at the expense of other, potentially informative dimensions. The traditional emphasis in the archaeological discussion of lithics upon the stylistic variability of tool forms has been largely excluded from the perspectives develped here. However, it is worth noting that as theoretical and ethnoarchaeological research into the adaptational significance of style in material culture develops (Plog 1983; Sackett 1977, 1982; Wiessner 1977; Wobst 1977) it may prove possible to integrate such considerations with the perspectives developed here.

At a more specific level, the importance of time scheduling in understanding subsistence and technological strategies need not be confined to discussions of hunter-gatherer adaptations. As noted by Flannery (1972), the importance of scheduling in agricultural societies can be seen to influence the organization of agricultural labour investments, religious and socio-political activities both within and between communities. In briefly considering the potential importance of time scheduling in agricultural production we can see that the organization of lithic technology may play an equally important role.

For many years the advent of food producing adaptations in Britain and the apparently rapid disappearance of Mesolithic adaptations during the mid-fourth millenium b.c. has presented an explanatory challenge to archaeologists. In seeking to understand the economic and social transformation marking the Late Mesolithic/Early Neolithic transition explanations have sought to balance competing views on the degree to which the new economic practices were adopted by native hunter-gatherer populations. It has been suggested here that much of the Later Mesolithic archaeological record may be understood in terms of strategies designed to cope with the risks and costs of subsistence schedules. A variety of strategies, ranging from controlled forest clearance, browse management and shellfish exploitation to the organization and structure of lithic technology have been discussed as attempts at limiting subsistence risks. Against this background of subsistence risk-reduction strategies the availability of new resource options capable, through investments of labour, of providing further risk-reduction benefits may be viewed as being consistent with long-established economic goals.

However, whilst direct evidence for the appearance of domesticated resource production in the context of the Later Mesolithic is, as yet, limited (see Williams 1985: 130 - 134), the adoption of, for example, cereal production would have introduced new scheduling demands. The importance of organizing labour at specific times for weeding, planting and harvesting would have imposed new scheduling demands which would represent a clear break with the sorts of scheduling envisaged for the Later Mesolithic. Perhaps, therefore, we might view the adoption of domesticated resource production as being a response to long-standing economic goals which produced a major discontinuity in scheduling behaviour. The point here is that in seeking to account for the transition to Neolithic economic and social practices it may prove informative to consider the Later Mesolithic context in terms of established subsistence schedules and goals.

Certainly, the adoption of domesticated resource production would have demanded new schedules for labour investment and the organization of populations in space and time. Within these new conditions of labour and settlement the organization of lithic procurement, for example, would have confronted specific problems. Reduced residential mobility may have left many communities isolated from lithic sources, and promoted the organization of, for want of a better term, lithic procurement task-groups. Clearly, the time and costs invested in such activity would need to be scheduled outside of the periods when labour and technology were needed for subsistence goals. In this way, the Neolithic may have seen the development of lithic organizational strategies differing markedly from those of the Later Mesolithic.

For archaeologists the challenge remains - to develop a theoretical and methodological framework within which to examine the organization and structure of lithic technology. It is to be hoped that as such work develops it may prove possible to ultimately establish a theory of material culture applicable to the full range of economic and social adaptations.

BIBLIOGRAPHY

ACKERLEY, N. W. (1978)
"Controlling pressure in experimental lithics research",
American Antiquity, 43(3): 480 - 482.

AHLÉN, I. (1965)
"Studies on the red deer, Cervus elaphus L., in Scandinavia.
III. Ecological investigations",
Viltrevy, 3 : 177 - 376.

ALDENDERFER, M. S. (1982)
"Methods of cluster validation for archaeology",
World Archaeology, 14 : 61 - 72.

ANDERSON, J. (1895)
"Notice of a cave recently discovered at Oban, containing human remains and a refuse-heap of shells and bones of animals, and stone and bone implements",
Proceedings of the Society of Antiquaries of Scotland,
29 (1894-5) : 211 - 30.

ANDERSON, J. (1898)
"Notes on the contents of a small cave or rock-shelter at Druimgarvies, Oban; and of three shell-mounds in Oronsay",
Proceedings of the Society of Antiquaries of Scotland,
32 (1897-8) : 298 - 313.

ANDERSON, J. M., BYRD, B. F., ELSON, M. D., McQUIRE, R. H., MENDOZA, R. G., STASKI, E., and WHITE, J. P. (1981),
"The deer hunters: Star Carr reconsidered",
World Archaeology, 13 (1) : 31 - 46.

ARMSTRONG, A. L. (1931)
"A late upper Aurignacian station in north Lincolnshire",
Proceedings of the Prehistoric Society of East Anglia,
6 : 335 - 339.

ARMSTRONG, A. L. (1932)
"North of England notes: Upper Palaeolithic and Mesolithic stations in north Lincolnshire",
Proceedings of the Prehistoric Society of East Anglia,
7 : 130.

ASCHER, R. (1961)
"Analogy in archaeological interpretation"
Southwestern Journal of Anthropology, 17 : 317 - 325.

AZOURY, I., and HODSON, F. R. (1973)
"Comparing Palaeolithic assemblages: Ksar Akil, a case study",
World Archaeology, 4 : 292 - 306.

BAILEY, G. N. (1975)
"The role of molluscs in coastal economies; the results of midden analysis in Australia", Journal of Archaeological Science, 2 : 45 -62.

BAILEY, G. N. (1983)
"Hunter-gatherer behaviour in prehistory: problems and perspectives",
In:
Hunter-Gatherer Economy in Prehistory, (ed. G. N. Bailey), Cambridge University Press, Cambridge : 1 - 6.

BAILEY, H. P. (1960)
"A method of determining the warmth and temperateness of climate", Geografiska Annaler, 43 (1) : 1 - 16.

BETTINGER, R. L. (1980)
"Explanatory/predictive models of hunter-gatherer adaptation",
In:
Advances in Archaeological Method and Theory 3, (ed. M. B. Schiffer)
Academic Press, New York : 189 - 255.

BETTINGER, R. L. (1982)
"Aboriginal exchange and territoriality in Owen's valley, California",
In:
Contexts for Prehistoric Exchange, (ed. J. E. Ericson and T. K. Earle)
Academic Press, New York : 103 - 127.

BINFORD, L. R. (1962)
"Archaeology as anthropology", American Antiquity, 28 (2) : 217 - 225.

BINFORD, L. R. (1964)
"A consideration of archaeological research design", American Antiquity, 29 (4) : 425 - 41.

BINFORD, L. R. (1968a)
"Methodological considerations of the archaeological use of ethnographic data",
In:
Man the Hunter, (ed. R. B. Lee and I. De Vore), Aldine, Chicago : 268 - 273.

BINFORD, L. R. (1968b)
"Post-pleistocene adaptations",
In:
New Perspectives in Arhcaeology, (ed. S. R. Binford and L. R. Binford), Chicago : 313 - 341.

BINFORD, L. R. (1972)
"Contemporary model building: paradigms and the current state of Palaeolithic research",
In:
Models of Archaeology, (ed. D. L. Clarke)
Methuen, London : 109 - 166.

BINFORD, L. R. (1973)
"Interassemblage variability - the Mousterian and the 'functional' argument",
In:
The Explanation of Culture Change,
(ed. C. Renfrew)
Duckworth, London : 227 - 254.

BINFORD, L. R. (1976)
"Forty-seven trips: a case study in the character of some formation processes of the archaeological record",
In:
Contributions to Anthropology: The Interior Peoples of Northern Alaska, (National Museum of Man Mercury Series, 49),
Ottowa : 299 - 351.

BINFORD, L. R. (1977)
"General Introduction",
In:
For Theory Building in Archaeology,
(ed. L. R. Binford)
Academic Press, New York : 1 - 10.

BINFORD, L. R. (1978a)
Nunamiut Ethnoarchaeology,
Academic Press, New York.

BINFORD, L. R. (1978b)
"Dimensional analysis of behaviour and site structure: learning from an Eskimo hunting stand",
American Antiquity, 43 (3) : 330 - 361.

BINFORD, L. R. (1979)
"Organization and formation processes: looking at curated technologies",
Journal of Anthropological Research, 35 (3) : 255 - 273.

BINFORD, L. R. (1980)
"Willow smoke and dog's tails: hunter-gatherer settlement systems and archaeological site formation",
American Antiquity, 45 (1) : 4 - 20.

BINFORD, L. R. (1981)
Bones: Ancient Men and Modern Myths,
Academic Press, New York.

BINFORD, L. R. (1982a)
"Meaning, inference and the material record",
In:
Ranking, Resource and Exchange: Aspects of the Archaeology of Early European Society,
(ed. C. Renfrew and S. Shennan),
Cambridge University Press : 160 - 163.

BINFORD, L. R. (1982b)
"The archaeology of place",
Journal of Anthropological Archaeology, 1 (1) : 5 - 31.

BINFORD, L. R. (1983)
In Pursuit of the Past: Decoding the Archaeological Record,
Thames and Hudson, G.D.R.

BINFORD, L. R., and BINFORD, S. R. (1966)
"A preliminary analysis of functional variability in the Mousterian of Levallois facies",
American Anthropologist, 68 (2), pt. 2 : 238 - 295.

BINFORD, L. R., and BINFORD, S. R. (1969)
"Stone tools and human behaviour",
Scientific American, 220 (4) : 70 - 84.

BINFORD, L. R., and O'CONNELL, J. F. (1985)
"An Alyawara day: the stone quarry",
Journal of Anthropological Research, 41 : 406 - 432.

BINFORD, L. R., and STONE, N. M. (1985)
"'Righteous rocks' and Richard Gould: some observations on misguided debate",
American Antiquity, 50 (1) : 151 - 153.

BISAT, W. S. (1939)
"The relationship of the basement clays at Dimlington, Bridlington and Filey Bays",
Naturalist : 133 and 161.

BISAT, W. S. (1940)
"Older and newer drift in East Yorkshire",
Proceedings of the Yorkshire Geological Society, 24 : 137.

BISHOP, W. W., and DICKSON, J. H. (1970)
"Radiocarbon dates related to the Scottish Late-glacial sea in the Firth of Clyde",
Nature, 227 : 480 - 482.

BLACKADDER, A. (1824)
"On the superficial strata of the Forth district",
Memoirs of the Wernerian Natural History Society,
5 : 424 - 441.

BLEED, P. (1983)
The Optimal Design of Hunting Weapons: Maintenance or Reliability
Manuscript in the possession of author.

BONNICHSEN, R. (1968)
"Note 2 from the experimental laboratory: flake geometrics",
Archaeological Society of Alberta Newsletter, 16 : 4 - 12.

BONSALL, J. C. (1978)
"The coastal factor in the Mesolithic settlement of north-west England",
In:
Proceedings of the Second International Symposium on the Mesolithic in Europe,
(ed. B. Gramsch), Potsdam.

BORDES, F. (1950)
"Principes d'une méthode d'étude des techniques de débitage et de la typolegie du Paléolithique ancien et moyen",
L'Anthropologie, 52 (1-2) : 19 - 34.

BORDES, F. (1973)
"On the chronology and contemporaneity of different palaeolithic cultures in France",
In:
The Explanation of Culture Change,
(ed. C. Renfrew)
Duckworth, London : 217 - 226.

BORDES, F., and BORDES, D. de SONNEVILLE (1970)
"The significance of variability in Palaeolithic assemblages",
World Archaeology, 2 (1) : 61 - 73.

BORDES, F., and CRABTREE, D. E. (1969)
"The Corbiac blade technique and other experiments",
Tebiwa, 12 (2) : 1 - 21.

BRADLEY, B. A. (1975)
"Lithic reduction sequences - a glossary and discussion",
In:
Lithic Technology - Making and Using Stone Tools,
(ed. E. Swanson)
Mouton, The Hague : 5 - 13.

BRADLEY, R. (1970)
"A Mesolithic assemblage from East Sussex",
Sussex Archaeology Society Occasional Paper 2,
Phillimore, London.

BRADLEY, R. (1984)
The Social Foundation of Prehistoric Britain,
Longman, London.

BRADLEY, R., and LEWIS, E. (1974)
"A Mesolithic site at Wakeford's Copse, Havant",
Rescue Archaeology in Hampshire, 2 : 5 - 18.

BRAMWELL, D. (1959)
"The excavation of Dowel Cave, East Sterndale 1958-9",
Derbyshire Archaeological Journal, 79 : 97 - 109.

BRAMWELL, D. (1971)
"Excavations at Fox Hole Cave, High Wheeldon, 1961-70",
Derbyshire Archaeological Journal, 91 : 1 - 19.

BRAMWELL, D. (1973)
Archaeology in the Peak District,
Hartington.

BRAMWELL, D. (1977)
"Report on work at Fox Hole for seasons 1974, 1975, 1976",
Peak Archaeological Society, 30.

BRITNELL, W. (1984)
"A barbed point from Porth-y-waen, Llanyblodwel, Shropshire",
Proceedings of the Prehistoric Society, 50 : 385 - 386.

BUCKLAND, P. C., and DOLBY, M. J. (1973)
"Mesolithic and later material from Misterton Carr, Notts. - an interim report",
Transactions of the Thoreton Society, 77 : 5 - 33.

BUCKLEY, F. (1924)
A Microlithic Industry of the Pennine Chain
Privately printed.

BURTON, J. (1980)
"Making sense of waste flakes: new methods for investigating the technology and economics behind chipped stone assemblages",
Journal of Archaeological Science, 7 (2) : 131 - 148.

CAHEN, D., KEELEY, L. H., and Van NOTEN, F. L. (1979)
"Stone tools, toolkits, and human behaviour in Prehistory",
Current Anthropology, 20 (4) : 661 - 682.

CALKIN, J. B. (1924)
"Pygmy and other flint implements found at Peacehaven",
Sussex Archaeological Collections, 65 : 224 - 241.

CALKIN, J. B. (1952)
"Some archaeological discoveries in the Isle of Purbeck: A Mesolithic site at Ulwell near Swanage",
Proceedings of the Dorset Natural History and Archaeological Society, 74 : 48 - 49.

CAMPBELL, J. B. (1969)
"Excavations at Creswell Crags: preliminary report",
Derbyshire Archaeological Journal, 89 : 47 - 58.

CANE, T., and HIGHAM, N. J. (1984)
"Summary excavation report: Tatton, Cheshire",
Proceedings of the Prehistoric Society, 50 : 389.

CARE. V. (1982)
"The collection and distribution of lithic raw materials during the Mesolithic and Neolithic periods in southern England",
Oxford Journal of Archaeology, 1 (3) : 269 - 285.

CARE, V. (1979)
"The production and distribution of Mesolithic axes in southern England",
Proceedings of the Prehistoric Society, 45 : 93 - 102.

CARLSTEIN, T. (1982)
Time Resources, Society and Ecology,
The Royal University of Lund Department of Geography,
Gleerup.

CATT, J. A., and PENNY, L. F. (1966)
"The Pleistocene deposits of Holderness, East Yorkshire",
Proceedings of the Yorkshire Geological Society, 35 : 375 - 420.

CAULIFIELD, S. (1978)
"Star Carr - An alternative view",
Irish Archaeological Forum, 5 : 15 - 22.

CHAPLIN, R. E. (1975)
"The ecology and behaviour of deer in relation to their impact on the environment of prehistoric Britain",
In:
The Effect of Man on the Landscape: the Highland Zone,
(ed. J. G. Evans, S. Limbrey and H. Cleere)
Council of British Archaeology - Research Report 11 : 40 - 42.

CHARLES, W. N., McCOWAN, D., and EAST, K. (1977)
"Selection of upland swards by red deer (Cervus elaphus L) on Rhum",
Journal of Applied Ecology, 14 : 55 - 64.

CHILDE, V. G. (1929)
The Danube in Prehistory,
Oxford.

CHILDE, V. G. (1956)
Piecing Together the Past,
New York.

CHURCHILL, D. M. (1962)
"The stratigraphy of the Mesolithic sites III and V at Thatcham, Berkshire",
Proceedings of the Prehistoric Society, 28 : 362 - 370.

CHURCHILL, D. M. (1965)
"The displacement of depositis formed at sea-level 6500 years ago in Southern Britain",
Quaternaria, 7 : 239 - 249.

CHURCHILL, D. M., and WYMER, J. J. (1965)
"The Kitchen-midden site at Westward HO!, Devon, England: ecology, age and relation to changes in land and sea level",
Proceedings of the Prehistory Society, 31 : 74 - 84.

CLAESON, C. F. (1968)
"Distance and human interaction",
Geografisker Annaler B, 50 : 142 - 161.

CLARK, J. G. D. (1932)
The Mesolithic Age in Britain,
Cambridge University Press, London.

CLARK, J. G. D. (1943a)
"A late Mesolithic settlement at Selmeston, Sussex",
Antiquaries Journal, 14 : 134 - 158.

CLARK, J. G. D. (1934b)
"The classification of a microlithic culture:
the Tardenoisian of Horsham",
Archaeological Journal, 90 : 52 - 77.

CLARK, J. G. D. (1936)
The Mesolithic Settlement of Northern Europe,
Cambridge University Press, London.

CLARK, J. G. D. (1938)
"Mesolithic industries from tufa deposits at Prestatyn,
Flintshire and Blaskenwell",
Proceedings of the Prehistoric Society, 4 : 330 - 334.

CLARK, J. G. D. (1947)
"Whales as an economic factor in prehistoric Europe",
Antiquity, 21 : 84 - 104.

CLARK, J. G. D. (1948)
"The development of fishing in Prehistoric Europe",
Antiquaries Journal, 28 : 44 - 85.

CLARK, J. G. D. (1950)
"Preliminary report on excavations at Star Carr, Seamer,
Scarborough, Yorkshire",
Proceedings of the Prehistoric Society, 16 : 109 - 129.

CLARK, J. G. D. (1952)
Prehistoric Europe: The Economic Basis,
Methuen, London.

CLARK, J. G. D. (1954)
Excavations at Star Carr,
Cambridge University Press, London.

CLARK, J. G. D. (1955)
"A microlithic industry from the Cambridgeshire fenland
and other industries of Sauvetterrian affinities in Britain",
Proceedings of the Prehistoric Society, 21 : 3 - 20.

CLARK, J. G. D. (1958)
"Blade and trapeze industries of the European stone age",
Proceedings of the Prehistoric Society, 24 : 24 - 52.

CLARK, J. G. D. (1968)
"Studies of Hunter-Gatherers as an aid to the interpretation of prehistoric societies",
In:
Man the Hunter, (ed. R. B. Lee and I. de Vore)
Aldine, Chicago : 276 - 280 and 289.

CLARK, J. G. D. (1972)
Star Carr: A Case Study in Bio-archaeology,
Addison Wesley Modular Publications 10,
Reading (Massachussetts).

CLARK, J. G. D. (1973)
"Seasonality and the interpretation of lithic assemblages",
In:
Estudios Dedicados al Profesor Dr. Luis Pericot,
Universidad de Barcelona: Instituto de Arqueologia y Prehistoria : 1 - 13.

CLARK, J. G. D., and GODWIN, H. (1956)
"A Maglemosian site at Brandesburton, Holderness, Yorkshire",
Proceedings of the Prehistoric Society, 22 : 6 - 22.

CLARK, J. G. D., and RANKINE, W. F. (1939)
"Excavations at Farnham, Surrey",
Proceedings of the Prehistoric Society, 5 (1) : 61 - 118.

CLARKE, D. L. (1968)
Analytical Archaeology (1st. edn.)
Methuen, London.

CLARKE, D. L. (1976)
"Mesolithic Europe: the economic basis",
In:
Problems in Economic and Social Archaeology,
(ed. G. Sieveking, I. H. Longworth, and K. E. Wilson)
Duckworth, London : 449 - 482.

CLASTRES, P. (1972)
"The Guayaki",
In:
Hunters and Gatherers Today,
(ed. H. G. Bicchieri)
Holt, Rinehart and Winston, New York,: 138 - 174.

CLOSE, A. E. (1978)
"The identification of style in lithic artefacts",
World Archaeology, 10 (2) : 223 - 237.

CLUTTON-BROCK, T. H., and HARVEY, P. H. (1978)
"Mammals, resources and reproductive strategies",
Nature, 273 : 191 - 195.

CLUTTON-BROCK, T. H., GUINESS, F. E., and ALBON, S. D. (1982)
Red Deer: Behaviour and Ecology of Two Sexes,
University of Chicago Press.

COLES, J. M. (1971)
"The early settlement of Scotland: excavations at Morton, Fife",
Proceedings of the Prehistoric Society, 37 : 284 - 366.

COLLINS, D. M. (1970)
"Stone artefact analysis and the recognition of culture traditions",
World Archaeology, 2 (1) : 17 - 27.

COLLINS, M. B. (1975)
"Lithic technology as a means of processual inference",
In:
Lithic Technology: Making and Using Stone Tools,
(ed. E. Swanson) Mouton, The Hague : 15 - 34.

CORMACK, W. F. (1970)
"A Mesolithic site at Barsalloch, Wigtownshire",
Transactions of the Dumfriesshire and Galloway Natural History and Antiquarians Society, 47 : 63 - 80.

CORMACK, W. F., and COLES, J. M. (1968)
"A Mesolithic site at Low Clone, Wigtownshire",
Transactions of the Dumfries and Galloway Natural History and Antiquarian Society, 45 : 44 - 72.

CORNWALL, I. W. (1968)
Prehistoric Animals and their Hunters,
London.

COUPLAND, G. (1948)
A Mesolithic Industry at 'The Beacon' S. E. Durham,
(privately printed, Gloucester).

COURTNEY, T., and PIERPOINT, S. J. (n.d.)
The excavation of a Mesolithic occupation site at Unstone, Derbyshire,
Manuscript on deposit at Sheffield City Museum, Weston Park.

COWLING, E. T., and MELLARS, P. A. (1973)
"A Mesolithic flint site: the Sandbeds, Otley, Yorkshire",
Yorkshire Archaeological Journal, 45 : 1 - 18.

COX, F. C., and BRIDGE, D. McC. (1977)
"The limestone and dolomite resources of the country around Monyash, Derbyshire",
Institute of Geological Sciences Mineral Assessment Report, 26.

CRABTREE, D. E. (1968)
"Mesoamerican polyhedral cores and prismatic blades",
American Antiquity, 33 (4) : 446 - 478.

CRABTREE, D. E. (1972)
"An introduction to flintworking.
Part II. A glossary of flintworking terms",
Occasional Papers of the Idaho State University Museum, 28.

CRABTREE, D. E. (1975)
"The potential of lithic technology"
In:
Primitive Technology and Art,
(ed. J. S. Raymond, B. Loveseth, C. Arnold, and G. Reardon)
University of Calgary : 1 - 6.

CRISP, D. J., and SOUTHWARD, A. J. (1958)
"The distribution of intertidal organisms along the coast of the English Channel",
Journal of the Marine Biological Association of the United Kingdom, 37 : 157 - 208.

DAMAS, D. (1972)
"The Copper Eskimo",
In:
Hunters and Gatherers Today,
(ed. M. G. Bicchieri)
Holt, Rinehart and Winston, New York : 3 - 50.

DANIEL, G. (1962)
The Idea of Prehistory,
C. A. Watts, London.

DARLING, F. (1969)
A Herd of Red Deer,
Oxford University Press.

DAVID, A. (1986)
"A possible later Mesolithic arrow from Seamer Carr, N. Yorks.",
Paper presented at the Palaeolithic/Mesolithic day meeting - Sheffield, 31st. January, 1986.

DAVIES, J. (1963)
"A Mesolithic site on Blubberhouses Moor, Wharfedale, West Riding of Yorkshire",
Yorkshire Archaeological Journal, 41 : 61 - 70.

DAVIES, J., and RANKINE, W. F. (1960)
"Mesolithic flint axes from the West Riding of Yorkshire",
Yorkshire Archaeological Journal, 40 : 209 - 214.

DEITH, M. R. (1983)
"Molluscan calendars: the use of growth-line analysis to establish seasonality of shellfish collection at the Mesolithic site of Morton, Fife",
Journal of Archaeological Science, 10 : 423 - 440.

DEGERBØL, M. (1964)
"Some remarks on Late- and Post-glacial vertebrate fauna and its ecological relations in northern Europe",
Journal of Animal Ecology, 33 (Supp.) : 71 - 85.

DENNELL, R. (1983)
European Economic Prehistory,
Academic Press, New York.

DERSAI, B. N. (1966)
"The biology of Monodonta lineata (Da Costa)",
Proceedings of the Malacological Society of London, 37 : 1 - 17.

DIMBLEBY, G. W. (1961)
"The ancient forest of Blackamore",
Antiquity, 35 : 123 - 8.

DIMBLEBY, G. W. (1962)
The Development of British Heathlands and their Soils,
University Press, Oxford.

DIMBLEBY, G. W. (1967)
Plants and Archaeology,
London.

DINGLE, H. (1980)
"Ecology and evolution of migration",
In:
Animal Migration, Orientation and Navigation,
(ed. S. A. Gauthreaux, Jr.)
Academic Press, New York : 1 - 110.

DONALD, L., and MITCHELL, D. H. (1975)
"Some correlates of local group rank among the Southern Kwakiutl",
Ethnology, 14 : 325 - 346.

DORAN, J. E., and HODSON, F. E. (1975)
Mathematics and Computers in Archaeology,
Edinburgh University Press.

DRAPER, J. C. (1968)
"Mesolithic distribution in south-east Hampshire",
Proceedings of the Hampshire Field and Archaeological Society,
23 : 110 - 119.

DUDLEY, H. (1949)
Early Days in North-West Lincolnshire,
W. H. and C. H. Coldicott, Scunthorpe.

DUNNELL, R. C. (1978)
" Style and function: a fundamental dichotomy",
American Antiquity, 43 (2) : 194 - 202.

DUNNELL, R. C. (1980)
"Evolutionary theory and archaeology",
In:
Advances in Archaeological Method and Theory 3
(ed. M. B. Schiffer)
Academic Press, New York : 35 - 99.

DUNNELL, R. C. (1982)
"Science, social science, and common sense: the agonizing dilemma of modern archaeology",
Journal of Anthropological Research, 38 (1) : 1 - 25.

DZIECIOLOWSKI, R. (1979)
"Structure and spatial organization of deer populations",
Acta Theriologica, 24 : 3 - 21.

EDWARDS, W., and TROTTER, F.M. (1954)
The Pennines and Adjacent Areas,
British Regional Geology - Institute of Geological Sciences,
H.M.S.O., London.

ERICSON, J. E. (1984)
"Towards the analysis of lithic production systems",
In:
Prehistoric Quarries and Lithic Production
(ed. J. E. Ericson and B. A. Purdy)
Cambridge University Press, Cambridge : 1 - 9.

ERDTMAN, G. (1928)
"Studies in the post-Arctic history of the forests of North Western Europe.
1. Investigations in the British Isles",
Geol. För. Stockh. Förh., 50 : 123 - 192.

EVANS, E. E. (1975)
"Highland landscapes: habitat and heritage",
In:
The Effect of Man on the Landscape: the Highland Zone,
(ed. J. G. Evans)
Council of British Archaeology Research Report 11 : 1 - 5.

EVANS, J. G. (1974)
What to do with Shellfish on Archaeological Sites,
Department of the Environment,
Central Office for Wales.

EVANS, J. G. (1975)
The Environment of Early Man in the British Isles,
Elek, London.

EVERITT, B. (1974)
Cluster Analysis,
Heinemann, London.

FAIRBRIDGE, R. W. (1961)
"Eustatic changes in sea-level",
Physics and Chemistry of the Earth, 4 : 99 - 185.

FEIT, H. (1973)
"The ethno-ecology of the Waswanipi Cree; or how hunters can manage their resources",
In:
Cultural Ecology,
(ed. B. Cox)
Carleton Library, Toronto : 115 - 125.

FINDLOW, F. J., and BOLOGNESE, M. (1982)
"Regional modelling of obsidian procurement in the American south-west",
In:
Contexts for Prehistoric Exchange,
(ed. J. E. Ericson and T. K. Earle)
Academic Press, New York : 53 - 81.

FLANNERY, K. V. (1972)
"Summary comments: evolutionary trends in social exchange and interaction",
In:
Social Exchange and Interaction,
(ed. E. N. Wilmsen),
Anthropological Papers, Museum of Anthropology,
University of Michigan, 46 : 129 - 135.

FOLEY, R. (1982)
"A reconsideration of the role of predation on large mammals in tropical hunter-gatherer adaptations",
Man, (N.S.) 17 : 393 - 402.

FORSMAN, M. R. A. (1975)
"Bipolar stone working technology",
In:
Primitive Art and Technology,
(ed. J. S. Raymond, B. Loveseth, C. Arnold, G. Reardon),
University of Calgary : 16 - 26.

FRANK, F. C., and LAWN, B. R. (1967)
"On the theory of Herzian fracture",
Royal Society Proceedings, 299A : 291 - 306.

FRASER, F. C., and KING, J. E. (1950)
"Second interim report on the animal remains from Star Carr, Seamer",
In:
"Preliminary report on excavations at Star Carr, Seamer, Scarborough, Yorkshire (second season 1950)",
Proceedings of the Prehistoric Society, 16 : 124 - 129.

FRASER, F. C., and KING, J. E. (1954)
"Faunal remains",
In:
Excavations at Star Carr,
(J. G. D. Clark)
Cambridge University Press, London : 70 - 95.

FREUD, S. (1933)
The Dissection of Psychical Personality,
New York.

FRIED, M. H. (1967)
The Evolution of Political Society,
Random House, New York.

FRISON, G. (1970)
"The Glenrock buffalo jump, 48CO304",
Plains Anthropologist, 15 (50) Memoir 7.

FRISON, G. (1974)
The Casper Site: A Hell Gap Bison Kill on the High Plains,
Academic Press, New York.

FRITZ, J. H., and PLOG, F. T. (1970)
"The nature of archaeological explanation",
American Antiquity, 35 : 405 - 412.

FROOM, F. R. (1963)
"The Mesolithic around Hungerford: parts 1 and 2",
Transactions of the Newbury and District Field Club, 11 (2) : 62 - 87.

FROOM, F. R. (1972)
"A Mesolithic site at Wawcott, Kintbury",
Berkshire Archaeological Journal, 66 : 23 - 44.

GAMBLE, C. S. (1978)
"Resource exploitation and the spatial patterning of hunter-gatherers: a case study",
In:
Social Organization and Settlement: Contributions from Anthropology, Archaeology and Geography,
British Archaeological Reports - International Series (Supplementary) 47 : 153 - 185.

GAMBLE, C. S. (1979)
"Hunting strategies in the central European Palaeolithic",
Proceedings of the Prehistoric Society, 45 : 35 - 52.

GARTON, D. (1980)
"An early Mesolithic site at Rackham, West Sussex",
Sussex Archaeological Collections, 118 : 145 - 152.

GODWIN, H. (1940a)
"Pollen analysis and forest history of England and Wales",
New Phytologist, 39 : 370 - 400.

GODWIN, H. (1940b)
"Studies of the Post-glacial history of British vegetation.
III. Fenland pollen diagrams.
IV. Post-glacial changes of relative land- and sea-level in the English Fenland",
Philosophical Transactions of the Royal Society of London B, 230 : 239 - 303.

GODWIN, H. (1941)
"Studies of the Post-glacial history of British vegetation.
VI. Correlations in the Somerset Levels",
New Phytologist, 40 : 108 - 132.

GODWIN, H. (1948)
"Studies of the Post-glacial history of British vegetation.
X. Correlations between climate, forest composition, prehistoric agriculture and peat stratigraphy in Sub-Boreal and Sub-Atlantic peats of the Somerset Levels",
Philosophical Transactions of the Royal Society of London B, 233 : 275 - 286.

GODWIN, H. (1956)
The History of the British Flora: A Factual Basis for Phytogeography,
Cambridge.

GODWIN, H. (1975)
The History of the British Flora (2nd. ed.),
Cambridge.

GODWIN, H., and GODWIN, M. E. (1933)
"British Maglemose harpoon sites",
Antiquity, 7 : 36 - 48.

GODWIN, H., SUGGATE, R. P., and WILLIS, E. H. (1958)
"Radiocarbon dating of the eustatic rise in ocean level",
Nature, 181 : 1518 - 1519.

GODWIN, H., and TALLANTIRE, P. A. (1951)
"Studies of the Post-glacial history of British vegetation.
XII. Hockham Mere, Norfolk",
Journal of Ecology, 39 : 285 - 307.

GODWIN, H., WALKER, D., and WILLIS, E. H. (1957)
"Radiocarbon dating and Post-glacial vegetation history: Scaleby Moss",
Proceedings of the Royal Society of London, B 147 : 352 - 366.

GOODMAN, M. E. (1944)
"The physical properties of stone tool materials",
American Antiquity, 9 : 415 - 433.

GOULD, R. A. (1968)
"Living archaeology: the Ngatatjara of Western Australia",
Southwestern Journal of Anthropology, 24 : 101 - 122.

GOULD, R. A. (1971)
"The archaeologist as ethnographer: a case from the Western Desert of Australia",
World Archaeology, 3 : 143 - 177.

GOULD, R. A. (1977)
"Ethnoarchaeology; or, where do models come from? A closer look at Australian lithic technology",
In:
Stone Tools as Cultural Markers,
(ed. R. V. S. Wright)
Canberra : 162 - 168.

GOULD, R. A. (1978a)
"Beyond analogy in ethnoarchaeology",
In:
Explorations in Ethnoarchaeology
(ed. R. A. Gould)
University of New Mexico Press, Albuquerque : 249 - 293.

GOULD, R. A. (1978b)
"The anthropology of human residues",
American Anthropologist, 80 : 815 - 836.

GOULD, R. A. (1980)
Living Archaeology,
Cambridge University Press, London.

GOULD, R. A. (1985)
"The empiricist strikes back: reply to Binford",
American Antiquity, 50 (3) : 638 - 644.

GOULD, R. A., KOSTER, D. A., and SONTZ, A. H. L. (1971)
"The lithic assemblage of the Western Desert Aborigines of Australia",
American Antiquity, 36 : 149 - 69.

GOULD, R. A., and SAGGERS, S. (1985)
"Lithic procurement in Central Australia: a closer look at Binford's idea of embeddedness in archaeology",
American Antiquity, 50 (1) : 117 - 135.

GOULD, R. A., and WATSON, P. (1982)
"A dialogue on the meaning and use of analogy in ethnoarchaeological reasoning",
Journal of Anthropological Archaeology, 1 (4) : 355 - 381.

GOULD, S. J. (1965)
"Is uniformitarianism necessary?"
American Journal of Science, 263 : 223 - 228.

GOULD, S. J. (1980)
Ever Since Darwin: Reflections in Natural History,
Pelican Books, Harmondsworth.

GRAY, N. F., and YESNER, D. R. (1978)
"Effects of human predation on predator-prey interaction: an example from the Aleutian Islands",
In:
Aleut Population and Ecosystem Analysis,
(ed. W. S. Laughlin and A. B. Harper).

GRIGSON, C. (1973)
The Comparative Craniology of Bos taurus L., B. indicus L., B. primigenius Bojanus and B. nomadicus,
Ph.D. thesis, University of London.

GRIGSON, C. (1978)
"The Late glacial and Early Flandrian ungulates of England and Wales - an interim review",
In:
The Effect of Man on the Lanscape: The Lowland Zone,
(ed. S. Limbrey and J. G. Evans),
Council of British Archaeology Research Report 21 : 46 - 56.

GRIGSON, C. (1986)
"Mesolithic overkill? The Great Auk on Oronsay",
Paper presented at the Palaeolithic/Mesolithic day meeting, Sheffield, 31st. January, 1986.

GUNN, J. (1975)
"Idiosyncratic behaviour in chipping style: some hypotheses and preliminary analysis",
In:
Lithic Technology: Making and Using Stone Tools,
(ed. E. Swanson)
Mouton, The Hague : 35 - 61.

HALLAM, J. S., EDWARDS, B. J. N., BARNES, B., and STUART, A. J. (1973)
"The remains of a late-glacial Elk associated with barbed points from High Furlong, near Blackpool, Lancashire",
Proceedings of the Prehistoric Society, 39 : 100 - 28.

HANCOCK, D. A., and URQUEHART, A.E. (1966)
"The fishery for cockles (Cardium edule L.) in the Burry Inlet, South Wales",
Fishery Investigations Series 11, 25 (3),
Ministry of Agriculture and Fisheries, H.M.S.O., London.

HARPENDING, H., and DAVIS, H. (1977)
"Some implications for hunter-gatherer ecology derived from the spatial structure of resources",
World Archaeology, 8 (3) : 275 - 287.

HARRIS, D. R. (1969)
"Agricultural systems, ecosystems and the origins of agriculture",
In:
The Domestication and Exploitation of Plants and Animals,
(ed. P. J. Ucko and G. W. Dimbleby)
Duckworth, London : 3 - 15.

HARRIS, M. (1979)
Cultural Materialism: The Struggle for a Science of Culture,
Random House, New York.

HARRISON, D. J. (1981)
Limestone and Dolomite Resources of the Country around Buxton, Derbyshire,
Institute of Geological Sciences - Mineral Assessment Report.

HARRISON, T. (1949)
"Notes on some nomadic Punans",
The Sarawak Museum Journal, V (1) : 130 - 146.

HART, C. R. (1981)
The North Derbyshire Archaeological Society,
Wigley and Sons, Leeds.

HASSAN, F. A. (1979)
"Demography and archaeology",
Annual Review of Anthropology, 8 : 137 - 60.

HAWKES, C. (1954)
"Archaeological theory and method:
some suggestions from the Old World",
American Anthropologist, 56 : 155 - 168.

HAWTHORNE, J. B. (1964)
"The eastern limit of distribution of Monodonta lineata (Da Costa) in the English Channel",
Journal of Conchology, 25 : 348 - 352.

HAYDEN, B. (1975)
"Curation: Old and new",
In:
Primitive Art and Technology,
(ed. J. S. Raymond, B. Loveseth, C. Arnold and G. Reardon)
University of Calgary : 47 - 59.

HAYDEN, B. (1977)
"Stone tool functions in the Western Desert",
In:
Stone Tools as Cultural Markers,
(ed. R. V. S. Wright)
Canberra.

HAYDEN, B. (1978)
"Snarks in archaeology: or inter-assemblage variability in lithics (a view from the Antipodes)",
In:
Lithics and Subsistence: The Analysis of Stone Tool Use in Prehistoric Economies,
(ed. D. L. Davis)
Vanderbilt University Publications in Anthropology 10 : 179 - 198.

HAYDEN, B. (1979)
Lithic Use-Wear Analysis,
Academic Press, New York.

HAYNES, R. (1974)
"Application of exponential distance decay to human and animal activities",
Geografisker Annaler, B 56.

HECK, L. (1950)
Schwarzwild: Lebensbild des Wildschweins,
Paul Parey, Hamburg.

HENSON, D. (1982)
Flint as a Raw Material in Prehistory,
M. Phil. thesis, University of Sheffield.

HEY, R. W. (1956)
"Cherts and limestones from the Crow series near Richmond, Yorkshire",
Proceedings of the Yorkshire Geological Society, 30 : 289 - 298.

HIBBERT, F. A., SWITSUR, V. R., and WEST, R. G. (1971)
"Radiocarbon datings of Flandrian pollen zones at Red Moss, Lancashire",
Proceedings of the Royal Society B, 177 : 161 - 176.

HIGGS, E. S. (1959)
"Excavations at a Mesolithic site at Downton, near Salisbury, Wilts."
Proceedings of the Prehistoric Society, 25 : 209 - 232.

HILL, K., and HAWKES, K. (1983)
"Neotropical hunting among the Ache of Eastern Paraguay",
In:
Adaptive Responses of Native Amazonians,
(ed. R. B. Hames and W. T. Vickers),
Academic Press, New York : 139 - 188.

HIRTH, K. G. (ed.) (1984)
Trade and Exchange in Early Mesoamerica,
University of New Mexico Press, Alberquerque.

HODDER, I. (1974)
"Regression analysis of some trade and marketing patterns",
World Archaeology, 6 (2) : 172 - 189.

HODDER, I., and ORTON, C. (1976)
Spatial Analysis in Archaeology,
New Studies in Archaeology 1,
Cambridge University Press.

HODSON, F. R. (1969a)
"Searching for structure within multivariate archaeological data",
World Archaeology, 1 (1) : 90 - 105.

HODSON, F. R. (1969b)
"Cluster analysis and archaeology:
some new developments and applications",
World Archaeology, 1 (2) : 299 - 320.

HODSON, F. R., SNEATH, P. H., and DORAN, J. E. (1966)
"Some experiments in the numerical analysis of archaeological data",
Biometrica, 53 (3 and 4) : 311 - 324.

HOLMBERG, A. R., (1950)
Nomads of the Long Bow: the Siriono of Eastern Bolivia,
Institute of Social Anthropology Publication 10.

HUDSON, R. G. S. (1924)
"On the rhythmic succession of the Yoredale Series in Wensleydale",
Proceedings of the Yorkshire Geological Society, 20 : 125 - 135.

HUDSON, R. G. S., and MITCHELL, G. H. (1937)
"The Carboniferous geology of the Skipton Anticline",
Sum. Prog. Geol. Surv., 1935, 2 : 1 - 45.

JACOBI, R. M. (1973)
"Aspects of the 'Mesolithic Age' in Great Britain",
In:
The Mesolithic in Europe,
(ed. S. Kozlowski),
Warsaw University Press : 237 - 266.

JACOBI, R. M. (1976)
"Britain inside and outside Mesolithic Europe",
Proceedings of the Prehistoric Society, 42 : 67 - 84.

JACOBI, R. M. (1978a)
"Northern England in the eigth millenium b.c.: an essay",
In:
The Early Postglacial Settlement of Northern Europe,
(ed. P. A. Mellars)
Duckworth, London : 295 - 332.

JACOBI, R. M. (1978b)
"Population and landscape in Mesolithic lowland Britain",
In:
The Effect of Man on the Landscape: The Lowland Zone,
(ed. S. Limbrey and J. G. Evans)
Council of British Archaeology Research Report 21 :
75 - 85.

JACOBI, R. M. (1978c)
"The Mesolithic of Sussex",
In:
Archaeology in Sussex to A.D. 1500,
(ed. P. L. Drewitt)
Council of British Archaeology Research Report 29 :
15 - 22.

JACOBI, R. M. (1979)
"Early Flandrian hunters in the South-West",
In:
Prehistoric Dartmoor in its Context,
Devon Archaeological Society 37 : 48 - 93.

JACOBI, R. M. (1980a)
"The Mesolithic in Essex",
In:
Archaeology in Essex to A.D. 1500,
(ed. G. Buckley)
Council of British Archaeology Research Report 34 :
14 - 25.

JACOBI, R. M. (1980b)
"The early Holocene settlement of Wales",
In:
Culture and Environment in Prehistoric Wales,
(ed. J. A. Taylor)
B.A.R. 76 : 131 - 206.

JACOBI, R. M. (1981)
"The last hunters in Hampshire",
In:
The Archaeology of Hampshire,
(ed. S. Shennan and T. Schadla Hall)
Hampshire Field Monograph 1 : 10 -25.

JACOBI, R. M. (1982)
"Later hunters in Kent: Tasmania and the earliest Neolithic",
In:
Archaeology in Kent to A.D. 1500,
(ed. P. E. Leach)
Council for British Archaeology Research Report 48 :
12 - 24.

JACOBI, R. M., TALLIS, J. H., and MELLARS, P. A. (1976)
"The Southern Pennine Mesolithic and the ecological record",
Journal of Archaeological Science, 3 : 307 - 320.

JARDINE, N., and SIBSON, R. (1968)
"The construction of hierarchic and non-hierarchic classifications",
Computer Journal, 11 : 117 - 184.

JARDINE, N., and SIBSON, R. (1971)
Mathematical Taxonomy,
Wiley, New York.

JARDINE, W. G. (1977)
"Location and age of Mesolithic coastal occupation sites on Oronsay, Inner Hebrides",
Nature, 267 : 138 - 140.

JARMAN, M. R. (1972)
"European deer economies and the advent of the Neolithic",
In:
Papers in Economic Prehistory,
(ed. E. S. Higgs)
Cambridge University Press : 125 - 147

JELINEK, A. J. (1976)
"Form, function and style in lithic analysis",
In:
Cultural Change and Continuity,
(ed. C. E. Cleland)
Academic Press, New York : 19 - 33.

JESSEN, K. (1949)
"Studies in late Quaternary deposits and floral-history of Ireland",
Proceedings of the Royal Irish Academy, B 52 : 85 - 290.

JOCHIM, M. A. (1976)
Hunter-Gatherer Subsistence and Settlement: A Predictive Model,
Academic Press, New York.

JOCHIM, M. A. (1979)
"Catches and caches: ethnographic alternatives for Prehistory",
In:
Ethnoarchaeology,
(ed. C. Kramer) : 219 - 246.

JONES, R. L. (1976)
"The activities of Mesolithic man: further palaeobotanical evidence from north-east Yorkshire",
In:
Geo-archaeology: Earth Science and the Past,
(ed. D. A. Davidson and M. L. Shackley)
Duckworth, London : 355 - 367.

JUKES-BROWN, A. J. (1885)
"The boulder clays of Lincolnshire",
Quarterly Journal of the Geological Society, 41 : 114.

KEEF, P. A. M., WYMER, J.J., and DIMBLEBY, G. W. (1965)
"A Mesolithic site on Iping Common, Sussex, England",
Proceedings of the Prehistoric Society, 31 : 85 - 92.

KEELEY, L. H. (1979)
Experimental Determination of Stone Tool Uses,
University of Chicago Press.

KEELEY, L. H. (1982)
"Hafting and retooling: effects on the archaeological record",
American Antiquity, 47 (4) : 798 - 809.

KEENE, A. S. (1981)
Prehistoric Foraging in a Temperate Forest,
Academic Press, New York.

KELLY, J. H. (1976)
The Excavation of Wetton Hill Rock Shelter, Manifold Valley, Staffordshire,
Stoke-on-Trent Museum Archaeological Society.

KELLY, R. L. (1983)
"Hunter-gatherer mobility strategies",
Journal of Anthropological Research, 39 (3) : 277 - 306.

KING, J. E. (1962)
"Report on the animal bones",
In:
"Excavations at the Maglemosian sites at Thatcham, Berkshire, England", (J. J. Wymer)
Proceedings of the Prehistoric Society, 28 : 329 - 361.

KLEINDIENST, M. R., and WATSON, P. J. (1956)
"Action archaeology: the archaeological inventory of a living community",
Anthropology Tomorrow, 5 (1) : 75 - 78.

KOLP, O. (1976)
"Submarine Uferterrazen der südichen Ost-und Nordsee als marken des Holzänen Meeransteigs und der Uberflutungsphasen der Ostsee",
Peterm. Geogr. Mitt., 120 : 1 -23.

KNUDSON, R. (1973)
Organizational Variability in Late Palaeo-Indian Assemblages,
Ph. D. Washington State University.

LACAILLE, A. D. (1951)
"A stone industry from Morar, Inverness-shire: its Obanian (Mesolithic) and later affinities",
Archaeologia, 94 : 103 - 39.

LACAILLE, A. D. (1954)
The Stone Age in Scotland,
London.

LAMB, H. H. (1966)
"Britain's climate in the past",
In:
The Changing Climate,
London : 170 - 195.

LAMB, H.H., LEWIS, R. P. W., and WOODRUFFE, A. (1966)
"Atmospheric circulation and the main climatic variables between 8000 and O.B.C.: meteorological evidence",
In:
World Climate from 8000 to O.B.C.,
(ed. J. S. Sawyer)
Royal Meteorological Society, London : 174 - 217.

LAMPLUGH, G. W. (1891)
"On the drifts of Flamborough Head",
Quarterly Journal of the Geological Society, 11 : 275.

LANCE, G. N., and WILLIAMS, W. T. (1967)
"A general theory of classificatory sorting strategies: 1. Hierarchical systems",
Computer Journal, 9 : 373 - 380.

LEAKEY, L. S. B. (1951)
"Abinger Common; Surrey. Preliminary Excavations",
Surrey Archaeological Society Rescue Report 3.

LEE, R. B. (1968)
"What hunters do for a living, or, how to make out on scarce resources",
In:
Man the Hunter,
(ed. R. B. Lee and I. de Vore)
Aldine, Chicago : 30 - 45.

LEE, R. B. (1969)
"!Kung bushmen subsistence: an input-output analysis",
In:
Environment and Cultural Behaviour,
(ed. A. P. Vayda)
Texas Press, Austin : 47 - 79.

LEE, R. B., and De VORE, I. (ed.) (1968a)
Man the Hunter,
Aldine, Chicago.

LEE, R. B., and De VORE, I. (1968b)
"Problems in the study of hunters and gatherers",
In:
Man the Hunter,
(ed. R. B. Lee and I. de Vore)
Aldine, Chicago : 3 - 12.

LEWIS, H. T. (1973)
"Patterns of Indian burning in California: ecology and ethnohistory",
Ballena Press Anthropological Papers, 1.

LEWIS, J. R. (1964)
The Ecology of Rocky Shores,
English Univerisities Press, London.

LINDLEY, D. V., and MILLER, J. C. P. (1953)
Cambridge Elementary Statistical Tables,
Cambridge University Press.

LOMAS, J. (1959)
"A Mesolithic site in South Derbyshire",
Derbyshire Archaeological Journal, 79 : 119 - 123.

LONGACRE, W. A., and AYRES, J. E. (1968)
"Archaeological theory: some lessons from an Apache wickiup",
In:
New Perspectives in Archaeology,
(ed. S. R. Binford and L. R. Binford)
Aldine, Chicago : 151 - 160.

LUSTIG-ARECCO, V. (1975)
Technology: Strategies for Survival,
Holt, Rinehart and Winston, New York.

LYNCH, F., and ALLEN, D. (1975)
"Brenig valley excavations, 1974",
Transactions of the Denbighshire Historical Society,
24 : 13 - 37.

MacARTHUR, R. H., and PIANKA, E. (1966)
"On optimal use of a patchy environment",
American Naturalist, 100 : 603 - 609.

MACKIE, E. W. (1972)
"Radiocarbon dates for two Mesolithic shell heaps and a Neolithic axe-factory in Scotland",
Proceedings of the Prehistoric Society, 38 : 412 - 416.

MANBY, T. G. (1963)
"Some Mesolithic sites in the Peak District and Trent basin",
Derbyshire Archaeological Journal, 83 : 10 - 23.

MANBY, T. G. (1966)
"A Creswellian site at Brigham, east Yorkshire",
Antiquaries Journal, 46 : 211 - 228.

MANDEVILLE, M. D. (1973)
"A consideration of the thermal pretreatment of chert",
Plains Anthropologist, 18 : 177 - 202.

MANN, L. McL. (1920)
"Oronsay period: discoveries at Risga",
Glasgow Herald, 21 August 1920.

MARGALEF, R. (1968)
Perspectives in Ecological Theory,
University of Chicago Press, Chicago.

MATTHEWS, B. (1977)
"Clay with flints on the Yorkshire and Lincolnshire Wolds",
Proceedings of the Yorkshire Geological Society,
41 (2) : 231 - 240.

McBRYDE, I. (1982)
Coast and Estuary: Archaeological Investigations on the North Coast of New South Wales at Wombah and Schnapper Point,
Australian Institute of Aboriginal Studies, Canberra.

MELLARS, P. A. (1969)
"Radiocarbon dates for a new Creswellian site",
Antiquity, 43 : 308 - 310.

MELLARS, P. A. (1970)
"Some comments on the notion of 'functional variability' in stone-tool assemblages",
World Archaeology, 2 (1) : 74 - 89.

MELLARS, P. A. (1970)
"An antler harpoon-head of 'Obanian' affinities from Whitburn, County Durham",
Archaeologia Aeliana, 48 : 337 - 347.

MELLARS, P. A. (1974)
"The Palaeolithic and Mesolithic",
In:
British Prehistory: a New Outline,
(ed. C. Renfrew)
Duckworth, London : 41 - 99.

MELLARS, P. A. (1975)
"Ungulate populations, economic patterns and the Mesolithic landscape",
In:
The Effect of Man on the Landscape: the Highland Zone,
(ed. J. G. Evans, S. Limbrey and H. Cleere)
Council of British Archaeology Research Report 11 :
49 - 56.

MELLARS, P. A. (1976a)
"Settlement patterns and industrial variability in the British Mesolithic",
In:
Problems in Economic and Social Archaeology,
(ed. G. de G. Sieveking, I. H. Longworth and K. Wilson)
Duckworth, London : 375 - 399.

MELLARS, P. A. (1976b)
"Fire ecology, animal populations and man:
A study of some ecological relationships in Prehistory",
Proceedings of the Prehistoric Society, 42 : 15 - 45.

MELLARS, P. A. (1976c)
"The appearance of 'narrow blade' microlithic industries in Britain: the radiocarbon evidence",
In:
Les Civilisations de 8e au 5e millénaire avant notre ère en Europe, Colloque 19,
9e Congrès Internationale des Sciences Préhistoriques et Protohistoriques, Nice : 166 - 174.

MELLARS, P. A. (1978)
"Excavation and economic analysis of Mesolithic shell-middens on the island of Oronsay (Inner Hebrides)",
In:
The Early Postglacial Settlement of Northern Europe,
(ed. P. A. Mellars)
Duckworth, London : 371 - 396.

MELLARS, P. A., and PAYNE, S. (1971)
"Excavation of two Mesolithic shell-middens on the island of Oronsay (Inner Hebrides)",
Nature, 231 : 397-398.

MELLARS, P. A., and REINHARDT, S. C. (1978)
"Patterns of Mesolithic land-use in southern England: a geological perspective",
In:
The Early Postglacial Settlement of Northern Europe,
(ed. P. A. Mellars)
Duckworth, London : 243 - 293.

MELMORE, S. (1935)
The Glacial Geology of Holderness and the Vale of York,
Arbroath.

MERCER, J. (1968)
"Stone tools from a washing-limit deposit of the highest post-glacial transgression, Lealt Bay, Isle of Jura",
Proceedings of the Society of Antiquaries of Scotland,
100 : 1 - 46.

MERCER, J. (1970)
"The Mesolithic succession in N. Jura, Argyll, W. Scotland",
Quaternaria, 13 : 177 - 185.

MERCER, J. (1971)
"A regression-time stone-worker's camp 33 ft. O.D., Lussa River, Isle of Jura",
Proceedings of the Society of Antiquaries of Scotland,
103 (1970 - 71) : 1 - 32.

MERCER, J. (1972)
"Microlithic and Bronze Age camps, 75 - 62 ft. O.D., N. Carn, Isle of Jura",
Proceedings of the Society of Antiquaries of Scotland, 104 (1971 - 72) : 1 - 22.

MILLWARD, R., and ROBINSON, A. (1975)
The Peak District,
Eyre Methuen, London.

MONEY, J. H. (1960)
"Excavations at High Rocks, Tunbridge Wells, 1954 - 1956",
Sussex Archaeological Collections, 98 : 173 - 221.

MONEY, J. H. (1962)
"Excavations at High Rocks, Tunbridge Wells, 1954 - 56",
Sussex Archaeological Collections, 100 : 149 - 151.

MOORE, J. W. (1950)
"Mesolithic sites in the neighbourhood of Flixton, north-east Yorkshire",
Proceedings of the Prehistoric Society, 16 : 101 - 108.

MOORE, P. D. (1975)
"Origin of blanket mites",
Nature, 256 : 267 - 269.

MORGAN, C. G. (1973)
"Archaeology and explanation",
World Archaeology, 4 (2) : 259 - 276.

MORRIS, D. B. (1898)
"Whale remains, prehistoric implements, etc., found at Causewayhead",
Transactions of the Stirlingshire Natural History and Archaeological Society, (1897 - 98) : 57 - 61.

MORRIS, D. B. (1925)
"The whale remains of the Carse of Stirling",
Scottish Naturalist, (1925) : 137 - 40.

MORRISON, A. (1980)
Early Man in Britain and Ireland,
Croom Helm, London.

MORROW, C. A., and JEFFERIES, R. W. (n.d.)
"Trade or embedded procurement: a test case from Southern Illinois",
Manuscript in author's possession.

MOVIUS, H. L. (1940)
"An early post-glacial archaeological site at Cushendum, C. Antrim",
Proceedings of the Royal Irish Academy, C 46 : 1 - 84.

MUSSON, C. R. (1975)
"Mesolithic activity in the Brenig valley",
In:
"Brenig Valley Excavations 1974 (Interim Report",
(ed. F. Lynch and D. Allen) : 30.
Denbighshire Historical Transactions 24 : 13 -37.

MUTO, G. R. (1971)
"A stage analysis of the manufacture of stone tools",
In:
Great Basin Anthropological Conference 1970: Selected Papers, (ed. C. M. Aitkens),
University of Oregon Anthropological Papers 1 : 109 - 118.

MYERS, A. M. (1978)
The Mesolithic Exploitation of Portland: An Ecological Approach to Shell-midden Analysis,
Undergraduate Dissertation, University of Sheffield.

MYERS, A. M., and GOURLAY, R. (in prep.)
"Preliminary investigation of a shell-midden at Muirtown, Inverness".

NAHLIK, A. J. de (1959)
Wild Deer,
Faber and Faber, London.

NEWCOMER, M. H. (1971)
"Some quantitative experiments in hand-axe manufacture",
World Archaeology, 3 (1) : 85 - 194.

NEWCOMER, M. H. (1975)
"'Punch technique' and Upper Palaeolithic blades",
In:
Lithic Technology: Making and Using Stone Tools,
(ed. E. Swanson)
Mouton, The Hague : 97 - 102.

NEWCOMER, M. H., and HODSON, F. R. (1973)
"Constellation analysis of burins from Ksar Akil",
In:
Archaeological Theory and Practice,
(ed. D. Strong)
Seminar Press, London : 87 - 104.

NOE-NYGAARD, N. (1974)
"Mesolithic hunting in Denmark illustrated by bone injuries caused by human weapons",
Journal of Archaeological Science, 1 : 217 - 248.

OBERG, K. (1973)
The Social Economy of the Tlingit Indians,
University of Washington Press, Seattle.

O'CONNELL, J. F., and HAWKES, K. (1984)
"Food choice and foraging sites among the Alyawara",
Journal of Anthropological Research, 40 (4) : 504 - 535.

OLSSON, G. (1965)
"Distance and human interaction:
a review and bibliography",
Regional Science Institute Bibliography, Series 2.

O'MALLEY, M. (1976)
"Broom Hill, Braishfield: Mesolithic dwelling",
Current Archaeology, 63 : 117 - 120.

O'MALLEY, M., and JACOBI, R. M. (1978)
"The excavation of a Mesolithic occupation site at Broom Hill,
Braishfield, Hampshire 1971 - 73",
Rescue Archaeology in Hampshire, 4 : 16 - 38.

ORME, B. (1973)
"Archaeology and ethnography",
In:
The Explanation of Culture Change,
(ed. C. Renfrew)
Duckworth, London : 481 - 492.

ORME, B. (1979)
"Boundaries of the forager's life",
In:
Prehistoric Dartmoor in its Context,
Devon Archaeological Society 37 : 195 - 202.

ORR, R. T. (1970)
Animals in Migration,
MacMillan, New York.

OSBORN, A. J. (1977)
"Strandloopers, mermaids and other fairy tales:
ecological determinants of marine resource utilization -
the Peruvian case",
In:
For Theory Building in Archaeology,
(ed. L. R. Binford)
Academic Press, New York : 157 - 205.

O'SHEA, J., and ZVELEBIL, M. (1984)
"Oleneostrovski mogilnik: reconstructing the social and
economic organization of Prehistoric foragers in Northern Russia",
Journal of Anthropological Archaeology, 3 : 1 - 40.

OSWALT, W. H. (1973)
Habitat and Technology,
Holt, Rinehart and Winston, New York.

OSWALT, W. H. (1976)
An Anthropological Analysis of Food-Getting Technology,
Wiley and Sons, New York.

PAINE, R. (1973)
"Animals as capital: comparisons among northern nomadic herders and hunters",
In:
Cultural Ecology,
(ed. B. Cox)
Carleton Library, Toronto.

PALMER, S. (1963)
"Prehistoric stone industries of the Fleet-area, Weymouth",
Proceedings of the Dorset Natural History and Archaeological Society, 85 : 107 - 115.

PALMER, S. (1967)
"Trial excavations in the Fleet area, Weymouth",
Proceedings of the Dorset Natural History and Archaeological Society, 88 : 152 - 157.

PALMER, S. (1969)
"A Mesolithic site at Portland Bill 1966",
Proceedings of the Dorset Natural History and Archaeological Society, 90 : 183 - 206.

PALMER, S. (1970a)
"The Mesolithic industries of Mother Siller's Channel, Christchurch, and the neighbouring areas",
Proceedings of the Hampshire Field Club and Archaeological Society, 25 : 9 - 32.

PALMER, S. (1970b)
"The stone age industries of the Isle of Portland, Dorset, and the utilisation of Portland chert as artefact material in southern England",
Proceedings of the Prehistoric Society, 36 : 82 - 115.

PALMER, S. (1976)
"The Mesolithic habitation site at Culver Well, Portland, Dorset; interim note",
Proceedings of the Prehistoric Society, 42 : 324 - 327.

PALMER, S. (1977)
Mesolithic Cultures in Britain,
Dolphin, Poole.

PALMER, S. (1983)
"Culverwell Mesolithic habitation site, Portland",
Proceedings of the Dorset Natural History and Archaeological Society, 104 : 170.

PEACOCK, J. D. (1971)
"Marine shell radiocarbon dates and the chronology of deglaciation in western Scotland",
Nature, 230 : 43 - 45.

PEACOCK, W. R. B. (1978)
"Probabalistic sampling in shell middens: a case study from Oronsay, Inner Hebrides",
In:
Sampling in Contemporary British Archaeology,
(ed. J. Charry, C. Gamble, and S. Shennan)
B.A.R. 50 : 177 - 190.

PEAKE, H. J. E., and CRAWFORD, O. G. S. (1922)
"A flint factory at Thatcham, Berkshire",
Proceedings of the Prehistoric Society of East Anglia,
3 : 499 - 514.

PENNINGTON, W. (1969)
The History of British Vegetation,
English Universities Press, London.

PERLMAN, S. M. (1980)
"An optimum diet model, coastal variability, and hunter-gatherer behaviour",
In:
Advances in Archaeological Method and Theory III,
(ed. M. B. Schiffer),
Academic Press, New York : 257 - 310.

PERRIN, R. M. S., ROSE, J., and DAVIES, H. (1979)
"The distribution, variation and origins of pre-Devensian tills in eastern England",
Philosophical Transactions of the Royal Society,
B 287 : 535 - 570.

PETCH, J. A. (1924)
Early Man in the District of Huddersfield,
Tolson Memorial Museum Publication 3,
Advertiser Press, Huddersfield.

PETERSSON, M. (1951)
"Microlithen als Pfeilspitzen. Ein fund aus dem Lilla-Loshult Moor: Ksp. Loshult, Skåne",
Meddelanden fran Lunds Universitets Historiska Museum : 123 - 137.

PETTIJOHN, F. J. (1957)
Sedimentary Rocks (2nd. edition)
New York.

PHEMISTER, J. (1926)
"The distribution of Scandinavian boulders in Britain",
Geological Magazine, 63 : 433 - 452.

PIDDOCKE, S. (1969)
"The potlatch system of the southern Kwakiutl: a new perspective",
In:
Environment and Cultural Behaviour,
(ed. A. P. Vayda)
Texas Press, Austin : 130 - 153.

PIERPOINT, S. J., and HART, C. R. (1980)
"A Mesolithic surface collection from Harry Hut Chunal Moor, Charlesworth, Derbyshire",
Derbyshire Archaeological Journal, 100 : 5 - 11.

PINGREE, R. D., and MADDOCK, L. (1977)
"Tidal eddies and costal discharge",
Journal of the Marine Biological Association of the United Kingdom, 57 : 869 - 875.

PITTS, M. (1978a)
"On the shape of waste flakes as an index of technological change in lithic industries",
Journal of Archaeological Science, 5 : 17 - 37.

PITTS, M. (1978b)
"Towards an understanding of flint industries in post-glacial England",
Bulletin of the Institute of Archaeology, University of London, 15 : 179 - 197.

PITTS, M. (1979)
"Hides and antlers: a new look at the gatherer-hunter site at Star Carr, North Yorkshire, England",
World Archaeology, 11 (1) : 32 - 42.

PITTS, M., and JACOBI, R. M. (1979)
"Some aspects of change in flaked stone industries of the Mesolithic and Neolithic in Southern Britain",
Journal of Archaeological Science, 6 : 163 - 177.

PLOG, F. T. (1974)
The Study of Prehistoric Change,
Academic Press, New York.

PLOG, F. T. (1975)
"Systems theory in archaeological research",
Annual Review of Anthropology, 8 : 207 - 224.

PLOG, S. (1983)
"Analysis of style in atefacts",
Annual Review of Anthropology, 12 : 125 - 142.

POINER, G. (1976)
"The process of the year among aborigines of the central and south coast of New South Wales",
Archaeology and Physical Anthropology in Oceania, 11 : 186 - 206.

POOLE, H. F. (1936)
"An outline of the Mesolithic flint cultures of the Isle of Wight",
Proceedings of the Isle of Wight Natural History and Archaeological Society, 2 (7) : 551 - 593.

PRAEGAR, R. L. (1896)
"Report upon the raised beaches of the north-east of Ireland with special reference to their fauna",
Proceedings of the Royal Irish Academy, 4 : 30 - 54.

PRAEGAR, R. L. (1888)
"The estuarine clays at the new Alexandra dock, Belfast, with a list of fossils",
Proceedings of the Belfast Naturalist Field Club, Appendix 2, 2 : 29 - 51.

PRICE, T. D. (1983)
"The European Mesolithic",
American Antiquity, 48 (4) : 761 - 777.

PRIOR, R. (1968)
The Roe Deer of Cranbourne Chase: An Ecological Survey,
Oxford University Press, London.

RADLEY, J. (1967)
"Excavations at a rock-shelter at Whaley, Derbyshire",
Derbyshire Archaeological Journal, 87 : 1 - 17.

RADLEY, J. (1968a)
"A Mesolithic structure at Sheldon, and a note on chert as a raw material on Mesolithic sites in the southern Pennines",
Derbyshire Archaeological Journal, 88 : 26 - 36.

RADLEY, J. (1968b)
"The Mesolithic period in north-east Yorkshire",
Yorkshire Archaeological Journal, 42 : 314 - 327.

RADLEY, J. (1969)
"A note on four Maglemosian bone points from Brandesburton, and a flint site at Brigham, Yorkshire",
Antiquaries Journal, 49 : 377 - 378.

RADLEY, J. (n.d.)
Radley Archive,
on deposit at Sheffield City Museum, Weston Park.

RADLEY, J., and MARSHALL, G. (1963)
"Mesolithic sites in south-west Yorkshire",
Yorkshire Archaeological Journal, 41 : 81 - 97.

RADLEY, J., and MARSHALL, G. (1965)
"Maglemosian sites in the Pennines",
Yorkshire Archaeological Journal, 41 : 394 - 402.

RADLEY, J., and MELLARS, P. A. (1964)
"A Mesolithic structure at Deepcar, Yorkshire, England, and the affinities of its associated flint industry",
Proceedings of the Prehistoric Society, 30 : 1 - 24.

RADLEY, J., TALLIS, J. H., and SWITSUR, V. R. (1974)
"Excavation of three 'narrow blade' Mesolithic sites in the Southern Pennines",
Proceedings of the Prehistoric Society, 40 : 1 - 19.

RAISTRICK, A. (1933)
"Mesolithic sites of the north-east coast of England",
Proceedings of the Prehistoric Society of East Anglia, 7 : 188 - 198.

RANKINE, W. F. (1936)
"A Mesolithic site at Farnham",
Surrey Archaeological Collections, 44 : 24 - 46.

RANKINE, W. F. (1949)
Mesolithic Survey of the West Surrey Greensand,
Research Papers of the Surrey Archaeological Society 2.

RANKINE, W. F. (1951)
"Artifacts of Portland chert in Southern England",
Proceedings of the Prehistoric Society, 17 : 93 - 94.

RANKINE, W. F. (1952)
"A Mesolithic chipping floor at The Warren, Oakhanger, Selborne, Hants.",
Proceedings of the Prehistoric Society, 23 : 35 - 59.

RANKINE, W. F. (1953)
"Mesolithic research in east Hampshire: the Hampshire Greensand",
Proceedings of the Hampshire Field Club, 18 : 21 - 35.

RANKINE, W. F. (1956)
The Mesolithic of Southern England,
Research Papers of the Surrey Archaeological Society 4.

RANKINE, W. F. (1961a)
"Mesolithic folk movements in southern England",
Archaeological Newsletter, 7 : 63 - 65.

RANKINE, W. F. (1961b)
"Further excavations at Oakhanger, Selborne, Hants. Site VIII",
Wealden Mesolithic Research Bulletin
(Privately printed) : 1 - 6.

RANKINE, W. F. (1961c)
"The Mesolithic age in Dorset",
Proceedings of the Dorset Natural History and Archaeological Society, 83 : 91 - 99.

RANKINE, W. F., RANKINE, W. M., and DIMBLEBY, G. W. (1960)
"Further excavations at a Mesolithic site at Oakhanger, Selborne, Hants.",
Proceedings of the Prehistoric Society, 26 : 246 - 262.

REAY, G. A., CUTT ING, C. L., and SHEWAN, J. M. (1946)
"The chemical composition of fish",
In:
The Nation's Food,
(ed. A. L. Bacharach and T. Rendle)
Society of Chemical Industries, London: 349.

REDMAN, C. L. (ed.) (1973)
Research and Theory in Current Archaeology,
Wiley and Sons, New York.

REID, C. (1896)
"An early Neolithic kitchen-midden and tufaceous deposit at Blashenwell",
Proceedings of the Dorset Natural History and Archaeological Society, 7 : 67 - 75.

REIDHEAD, V. A. (1980)
"The economics of subsistence change: a test of an optimization model",
In:
Modelling Change in Prehistoric Subsistence Economies,
(ed. T. K. Earle and A. L. Christenson),
Academic Press, New York : 141 - 186.

RENFREW, C. (1969)
"Trade and culture process in European Prehistory",
Current Anthropology, 10 : 151 - 169.

RENFREW, C. (1975)
"Trade as action at a distance: questions of interaction and communication",
In:
Ancient Civilization and Trade,
(ed. J. A. Sabloff and C. C. Lamberg-Karlovsky)
University of New Mexico Press, Albuquerque : 3 - 59.

RENFREW, C. (1977)
"Alternative models for exchange and spatial distribution",
In:
Exchange Systems in Prehistory,
(ed. T. K. Earle and J. E. Ericson)
Academic Press, New York : 71 - 90.

RENFREW, C., DIXON, J. E., and CANN, J. R. (1968)
"Further analyses of Near Eastern Obsidian",
Proceedings of the Prehistoric Society, 32 : 30 - 72.

ROBINSON, D. N. (1968)
"Soil erosion by wind in Lincolnshire, March, 1968",
East Midland Geographer, 4 : 351 - 362.

ROWLEY-CONWY, P. A. (1981)
"Mesolithic Danish bacon: permanent and temporary sites in the Danish Mesolithic",
In:
Economic Archaeology,
(ed. J. A. Sheridan and G. N. Bailey)
B.A.R. International Series 96 : 51 - 56.

ROWLEY-CONWY, P. A. (1983)
"Sedentary hunters: the Ertebolle example",
In:
Hunter-Gatherer Economy in Prehistory,
(ed. G. N. Bailey)
Cambridge University Press, Cambridge : 111 - 126.

ROWLEY-CONWY, P. A. (1984)
"The laziness of the short-distance hunter: the origins of agriculture in Western Denmark",
Journal of Anthropological Archaeology, 3 (4) : 300 - 324.

ROZOY, J. G. (1978)
Les Derniers Chassers, Tomes 1 and 2,
Bulletin de la Societie Archaeologique Champenoise.

RUSSELL, G. E. (1967)
"Impact Flutes",
Journal of Alabama Archaeology, 13 (1) : 66 - 67.

SABLOFF, J., and WILLEY, G. R. (1967)
"The collapse of Maya Civilization in the Southern lowlands",
Southwestern Journal of Anthropology, 23 : 311 - 336.

SACKETT, J. R. (1973)
"Style, function and artefact variability in Palaeolithic assemblages",
In:
The Explanation of Culture Change,
(ed. C. Renfrew)
Duckworth, London : 317 - 325.

SACKETT, J. R. (1977)
"The meaning of style in archaeology: a general model",
American Antiquity, 42 : 369 - 80.

SACKETT, J. R. (1982)
"Approaches to style in lithic archaeology",
Journal of Anthropological Archaeology, 1 : 59 - 112.

SAHLINS, M. D. (1972)
Stone Age Economics,
Aldine, Chicago.

SAHLINS, M., and SERVICE, E. R. (ed.) (1960)
Evolution and Culture,
University of Michigan Press, Ann Arbor.

SANGER, D. (1981)
"An alternative approach to Norwegian Mesolithic chronology",
Norwegian Archaeological Review, 14 (1) : 39 - 43.

SCHALK, R. F. (1977)
"The structure of an anadramous fish resource",
In:
For Theory Building in Archaeology,
(ed. L. R. Binford),
Academic Press, New York : 207 - 249.

SCHOENER, T. W. (1971)
"Theory of feeding strategies",
Annual Review of Ecology and Systematics, 2 : 369 - 404.

SEMENOV, S. A. (1964)
Prehistoric Technology,
Cory, Adams and Mackay, London.

SERVICE, E. R. (1962)
Primitive Social Organization,
Random House, New York.

SHARP, L. (1952)
"Steel axes for stone-age Australians",
In:
Human Problems in Technological Change,
(ed. E. H. Spicer)
Russel Sage, New York : 69 - 90.

SHARP, L. H. (1968)
"Discussions, Part VI",
In:
Man the Hunter,
(ed. R. B. Lee and I. de Vore)
Aldine, Chicago : 288 - 289.

SHEETS, P. D. (1975)
"Behavioural analysis and the structure of a prehistoric industry",
Current Anthropology, 16 : 369 - 391.

SHEETS, P. D., and MUTO, G. (1972)
"Pressure blades and total cutting edge: an experiment in lithic technology",
Science, 175 : 632 - 633.

SHERIDAN, R., SHERIDAN, D., and HASSELL, P. (1963)
"Rescue excavation of a Mesolithic site at Greenham Dairy Farm, Newbury, 1963",
Transactions of the Newbury and District Field Club, 11 (4) : 66 - 73.

SHIRLEY, J., and HORSFIELD, E. L. (1940)
"The Carboniferous Limestone of the Castleton - Bradwell area, North Derbyshire",
Quarterly Journal of the Geological Society of London, 96 : 271 - 299.

SIDRYS, R. (1976)
"Classic Maya obsidian trade",
American Antiquity, 41 : 449 - 464.

SILBERBAUER, G. B. (1972)
"The G/Wi Bushmen",
In:
Hunters and Gatherers Today,
(ed. M. G. Bicchieri)
Holt, Rinehart and Winston, New York : 271 - 326.

SIMMONS, I. G. (1964)
"Pollen diagrams from Dartmoor",
New Phytologist, 63 : 165 - 180.

SIMMONS, I. G. (1969a)
"Pollen diagrams from the North York Moors",
New Phytologist, 68 : 807 - 827.

SIMMONS, I. G. (1968b)
"Evidence for vegetation changes associated with Mesolithic man in Britain",
In:
The Domestication and Exploitation of Plants and Animals,
(ed. P. J. Ucko and G. W. Dimbleby)
Duckworth, London : 113 - 120.

SIMMONS, I. G. (1975a)
"Towards an ecology of Mesolithic Man in the uplands of Great Britain",
Journal of Archaeological Science, 2 : 1 - 15.

SIMMONS, I. G. (1975b)
"The ecological setting of Mesolithic Man in the Highland Zone",
In:
The Effect of Man on the Lanscape: the Highland Zone,
(ed. J. G. Evans, S. Limbrey and H. Cleere)
Council of British Archaeology Research Report 11 :
57 - 63.

SIMMONS, I. G. (1979)
"Late Mesolithic societies and the environment of the uplands of England and Wales",
University of London Institute of Archaeology Bulletin,
16 : 111 - 129.

SIMMONS, I. G., and CUNDILL, P. R. (1974)
"Late Quaternary vegetational history of the North York Moors.
1. Pollen analyses of blanket peats.
2. Pollen analyses of landslip bogs",
Journal of Biogeography, 1 : 159 - 169 and 253 - 261.

SIMMONS, I. G., and DIMBLEBY, G. W. (1974)
"The possible role of ivy (Hedera helix L.) in the Mesolithic economy of Western Europe",
Journal of Archaeological Science, 1 : 291 - 296.

SIMMONS, I. G., DIMBLEBY, G. W., and GRIGSON, C. (1981)
"The Mesolithic",
In:
The Environment in British Prehistory,
(ed. I. G. Simmons and M. Tooley)
Duckworth, London : 82 - 124.

SIMMONS, I. G., and INNES, J. B. (1981)
"Tree remains in a North York Moors peat profile",
Nature, 294 : 76 - 78.

SLOANE, D. (1982)
"Nether Kinneil",
Current Archaeology, 84 : 13 - 15.

SMILEY, F. E., SINOPOLI, C. M., JACKSON, H. E., WILLS, W. H., and GREGG, S. A. (ed.) (1980)
The Archaeological Correlates of Hunter-Gatherer Societies: Studies from the Ethnographic Record,
Michigan Discussions in Anthropology 1 and 2.

SMITH, A. G. (1970)
"The influence of Mesolithic and Neolithic man on British vegetation: a discussion",
In:
Studies in the Vegetational History of the British Isles: Essays in Honour of Harry Godwin,
Cambridge : 81 - 96.

SMITH, E. S. (1979)
"Human adaptation and energetic efficiency",
Human Ecology, 7 : 53 - 74.

SMITH, M. A. (1955)
"The limitations of inference in archaeology",
Archaeological Newsletter, 6 : 1 - 7.

SMITH, R. T. (1982)
Towards a More Wholistic View of British Vegetation History,
Working Paper no. 328, School of Geography,
University of Leeds.

SNEATH, P. H. A. (1969)
"Evaluation of clustering methods",
In:
Numerical Taxonomy, (ed. J. A. Cole)
Academic Press, New York.

SPENCE, M. W. (1984)
"Craft production and polity in early Teotihuacán",
In:
Trade and Exchange in Early Mesoamerica,
(ed. K. G. Hirth),
University of New Mexico Press, Albuquerque.

SPENCER, R. F. (1971)
The North Alaskan Eskimo:
A Study in Ecology and Society,
Dover Publications, New York.

SPETH, J. D. (1972)
"Mechanical basis of percussion flaking",
American Antiquity, 37 : 34 - 60.

SPETH, J. D. (1974)
"Experimental investigations of hard hammer percussion flaking",
Tebiwa, 17 : 7 - 36.

SPETH, J. D. (1975)
"Miscellaneous studies in hard hammer percussion flaking:
the effects of oblique impact",
American Antiquity, 40 : 203 - 207.

SPIER, R. F. G. (1975)
"Skill as a component of technological complexity",
In:
Primitive Art and Technology,
(ed. J. S. Raymond, B. Loveseth, C. Arnold and G. Reardon)
University of Calgary : 162 - 166.

SPRATT, D. A., GODDARD, R. E., and BROWN, D. R. (1976)
"Mesolithic settlement sites at Upleatham, Cleveland",
Yorkshire Archaeological Journal, 48 : 19 - 26.

STAINES, W. B. (1976)
"The use of natural shelter by red deer in N. E. Scotland",
Journal of Zoology, 180 : 1 - 8.

STAINES, B. W. (1977)
"Factors affecting the seasonal distribution of red deer (Cervus elaphus L.) in Glen Dye, N. E. Scotland",
Annals of Applied Biology, 87 : 495 - 512.

STEVENSON, I. P., and GAUNT, G. D. (1971)
Geology of the Country Around Chapel-en-le-Frith,
Memoirs of the Geological Survey of Great Britain,
H.M.S.O., London.

STEWARD, J. H. (1936)
"The economic and social basis of primitive bands",
In:
Essays in Anthropology Presented to A. L. Kroeber,
University of California Press, Berkley.

STEWARD, J. H. (1938)
Basin-Plateau Aboriginal Socio-Political Groups,
Smithsonian Institution Bureau of American Ethnology Bulletin 143,
U.S. Government Printing Office, Washington D.C.

STEWARD, J. H. (1942)
"The direct historical approach to archaeology",
American Antiquity, 7 (4) : 337 - 343.

STEWARD, J. H. (1955)
Theory of Culture Change,
University of Illinois, Urbana.

STEWART, O. C. (1956)
"Fire as the first great force employed by Man",
In:
Man's Role in Changing the Face of the Earth,
(ed. W. L. Thomas),
The University Press, Chicago : 115 - 133.

STILES, D. (1977)
"Ethnoarchaeology: a discussion of methods and applications",
Man, (n.s.), 12 : 87 - 103.

STONEHOUSE, W. P. B. (1972)
"Rocher Moss South: report on a recently excavated Mesolithic flint site in Saddleworth",
Saddleworth Historical Society Bulletin,
2 : 36 - 40.

STONEHOUSE, W. P. B. (1976)
"Red Ratcher: the excavation of a Mesolithic site in the Peak National Park",
Saddleworth Historical Society Bulletin, 6 : 15 - 22.

STONEHOUSE, W. P. B. (1978)
"White Hassock: prehistoric arrowheads",
Saddleworth Historical Society Bulletin, 8 : 1 - 3.

STONEHOUSE, W. P. B. (1980)
"Rocher Moss South 2: a later Mesolithic site in Saddleworth",
Saddleworth Historical Society Bulletin, 10 : 21 - 24.

STRAUS, L. G. (1980)
"The role of raw materials in lithic assemblage variability",
Lithic Technology, 9 : 68 - 72.

STRAW, A. (1969a)
"Pleistocene events in Lincolnshire - a survey and revised nomenclature",
Transactions of the Lincolnshire Naturalists Union, 17 : 85 - 100.

STRAW, A. (1969b)
Lincolnshire Soils,
Lincolnshire Natural History Brochure 3,
Lincolnshire Naturalists Union, Lincoln.

SUMMERS, P. G. (1941)
"A Mesolithic site near Iwerne Minster, Dorset",
Proceedings of the Prehistoric Society, 7 : 145 - 146.

SUTTLES, W. (1968)
"Coping with abundance: subsistence on the Northwest Coast",
In:
Man the Hunter,
(ed. R. B. Lee and I. de Vore)
Aldine, Chicago : 56 - 68.

SWADLING, P. (1976)
"Changes induced by human exploitation in Prehistoric shellfish populations",
Mankind, 10 (3) : 156 - 162.

SWITSUR, V. R., and JACOBI, R. M. (1975)
"Radiocarbon dates for the Pennine Mesolithic",
Nature, 256 : 32 - 34.

TAYLOR, H. (1927)
"King Arthur's Cave, near Whitchurch, Ross-on-Wye",
Proceedings of the Bristol University Speliological and Geological Society, 3 (1) : 59 - 83.

TAYLOR, J. A. (1975)
"The role of climatic factors in environmental and cultural changes in prehistoric times",
In:
The Effect of Man on the Landscape: the Highland Zone,
(ed. J. G. Evans, S. Limbrey and H. Cleere)
Council of British Archaeology Research Report 11 :
6 - 19.

TAYLOR, W. W. (1948)
"A Study of Archaeology",
American Anthropologist, 50 (2) - Memoir 69.

THOMSON, D. F. (1939)
"The seasonal factor in human culture",
Proceedings of the Prehistoric Society, 10 : 209 - 221.

TOMS, G. S. G. (1967)
"Interim report of excavations at Newfoundland Wood, Church Knowle",
Proceedings of the Dorset Natural History and Archaeological Society, 89 : 141 - 143.

TOOLEY, M. J. (1974)
"Sea-level changes during the last 9000 years in north-west England",
Geographical Journal, 140 : 18 - 42.

TOOLEY, M. J. (1976)
"Flandrian sea-level changes in west Lancashire and their implications for the 'Hillhouse Coastline'",
Geological Journal, 11 (2) : 37 - 52.

TOOLEY, M. J. (1978)
Sea-level Changes in North-West England During the Flandrian Stage,
Oxford.

TORRENCE, R. (1979)
"A technological approach to Cycladic blade industries",
In:
Papers in Cycladic Prehistory,
(ed. J. L. Davis and J. F. Cherry),
Monograph 14, Institute of Archaeology,
University of California, Los Angeles : 66 - 85.

TORRENCE, R. (1983)
"Time budgeting and hunter-gatherer technology",
In:
Hunter-Gatherer Economy in Prehistory,
(ed. G. N. Bailey),
Cambridge University Press, London : 11 - 22.

TOWNSEND, W. H. (1969)
"Stone and steel use in a New Guinea society",
Ethnology, 8 : 199 - 205.

TROELS-SMITH, J. (1960)
"Ivy, mistletoe and elm: climatic indicators - fodder plants: a contribution to the interpretation of the pollen zone border VII - VIII",
Danm. Geol. Unders., IV Series, 4 (4) : 1 - 32.

TUGGLE, H. D., TOWNSEND, A. H., and RILEY, T. J. (1972)
"Laws, systems and research designs: a discussion of explanation in archaeology",
American Antiquity, 37 : 3 - 12.

TURNER, J., and HODGSON, J. (1979)
"Studies in the vegetational history of the northern Pennines. I. Variations in the composition of the early Flandrian forests",
Journal of Ecology, 67 : 629 - 646.

TURNER, J., and HODGSON, J. (1983)
"Studies on the vegetational history of the northern Pennines. 3. Variations in the composition of the mid-Flandrian forests",
Journal of Ecology, 71 : 95 - 118.

TURNER, W. (1895)
"On human and animal remains found in caves at Oban, Argyllshire",
Proceedings of the Society of Antiquaries of Scotland, 29 (1894 - 95) : 410 - 438.

TURNER, W. (1889)
"On some implements of stag's horn associated with whales' skeletons found in the Carse of Stirling",
Report of the British Association : 789 - 791.

VITA-FINZI, C., and HIGGS, E. S. (1970)
"Prehistoric economy in the Mount Carmel area of Palestine: site catchment analysis",
Proceedings of the Prehistoric Society, 36 : 1 - 37.

WAINWRIGHT, G. J. (1959)
"The excavation of a Mesolithic site at Freshwater West, Pembrokeshire",
Bulletin Board for Celtic Studies, 18 : 196 - 205.

WAINWRIGHT, G. J. (1960)
"Three microlithic industries from south-west England and their affinities",
Proceedings of the Prehistoric Society, 26 : 193 - 201.

WALKER, D. (1956)
"A site at Stump Cross, Grassington, Yorkshire, and the age of the Pennine Microlithic industry",
Proceedings of the Prehistoric Society, 22 : 23 - 28.

WALKER, D., and GODWIN, H. (1954)
"Lake stratigraphy, pollen-analysis and vegetational history", In:
Excavations at Star Carr,
(J. G. D. Clark),
Cambridge : 25 - 69.

WARREN, S. H., CLARK, J. G. D., GODWIN, M. E., and MacFAYDEN, W. A. (1934)
"An early Mesolithic site at Broxbourne sealed under Boreal peat",
Journal of the Royal Anthropological Institute,
64 : 101 - 128.

WATSON, P. J., LeBLANC, S. A., and REDMAN, C. L. (1971)
Explanation in Archaeology: An Explicitly Scientific Approach,
Columbia University Press, New York.

WELLS, A. J. (1955)
"The development of chert between the Main and Crow limestones in North Yorks.",
Proceedings of the Yorkshire Geological Society,
30 : 117 - 124.

WEYMOUTH, J. W., and MANDEVILLE, M. (1975)
"An X-ray diffraction study of heat-treated chert and its archaeological implications",
Archaeometry, 17 (1) : 61 - 67.

WHEAT, J. B. (1982)
The Olsen-Chubbock Site: A Paleoindian Bison Kill,
Scoiety for American Archaeology Memoir 26.

WHEELER, A. (1978)
"Why were there no fish remains at Star Carr?"
Journal of Archaeological Science, 5 : 85 - 89.

WHITE, G. F. (1971)
Excavation of the Dead Man's Cave, North Anston,
Borough Library and Museum, Worksop.

WHITE, J. P. (1968)
"Fabricators, outils écaillés or scalar cores?"
Mankind, 6 (12) : 658 - 666.

WHITE, J. P., and MODJESKA, N. (1978)
"Acquirers, users, finders, losers: the use axe blades make of the Duna",
Mankind, 11 : 276 - 287.

WHITTLE, A. (1977)
The Earlier Neolithic of Southern England and its Continental Background,
B.A.R. supp. ser. 35.

WIESSNER, P. (1977)
Hxaro: A Regional System of Reciprocity for Reducing Risk Among the !Kung San,
Ph. D. Thesis, University of Michigan, Ann Arbor.

WILLEY, G. R., and PHILLIPS, P. (1958)
Method and Theory in American Archaeology,
University of Chicago Press, Chicago.

WILLIAMS, C. T. (1985)
Mesolithic Exploitation Patterns in the Central Pennines,
B.A.R. 139.

WILLIAMS, W. T., LANCE, G. N., DALE, M. B., and CLIFFORD, H. T. (1971)
"Controversy concerning the criteria for taxonomic strategies",
Computer Journal, 14 : 162 - 165.

WILMSEN, E. (1973)
"Interaction, spacing behaviour and the organization of hunting bands",
Journal of Anthropological Research, 29 : 1 - 31.

WINTERHALDER, B., and SMITH, E. A. (ed.) (1980)
Hunter-Gatherer Foraging Strategies,
University of Chicago Press, Chicago.

WILSON, V. (1948)
East Yorkshire and Lincolnshire,
British Regional Geology - Institute of Geological Sciences,
H.M.S.O., London.

WISHART, D. (1978)
Clustan: User Manual (3rd. Ed.)
Inter-University Research Councils Series Report 47.

WITTHOFT, J. (1969)
"Lithic materials and technology",
Proceedings, 25th Southeastern Archaeological Conference, Bulletin, 9 : 3 - 15.

WOBST, H. M. (1977)
"Stylistic behaviour and information exchange",
In:
"Papers for the Director: Research Essays in Honour of James B. Griffin",
(ed. C. E. Cleland)
Anthropological Papers, Museum of Anthropology, University of Michigan, 61 : 317 - 42.

WOOD, C. J., and SMITH, E. G. (1978)
"Lithographical classification of the chalk in north Yorkshire, Humberside and Lincolnshire",
Proceedings of the Yorkshire Geological Society,
42 : 263 - 282.

WOODCOCK, A. G. (1973)
The Nature of the Horsham Industry and its Place Within the British Mesolithic,
Chichester Museum Occasional Paper 1.

WOODMAN, P. C. (1978)
"The chronology and economy of the Irish Mesolithic: some working hypotheses",
In:
The Early Postglacial Settlement of Northern Europe,
(ed. P. A. Mellars),
Duckworth, London : 333 - 369.

WORDSWORTH, J. (1985)
"A Mesolithic horizon at 13-14 Castle Street, Inverness",
Proceedings of the Society of Antiquaries of Scotland,
117 (1985-86) - forthcoming.

WRIGHT, C. W., and WRIGHT, E. V. (1942)
"The chalk of the Yorkshire Wolds",
Proceedings of the Geological Association, 53 : 112 - 123.

WYMER, J. J. (1962)
"Excavations at the Maglemosian sites at Thatcham, Berkshire",
Proceedings of the Prehistoric Society, 28 : 329 - 361.

WYMER, J. J. (1977)
Gazeteer of Mesolithic Sites in England and Wales,
Council of British Archaeology Research Report 20.

YELLEN, J. E. (1977)
Archaeological Approaches to the Present,
Academic Press, New York.

YELLEN, J., and HARPENDING, H. (1972)
"Hunter-gatherer populations and archaeological inference",
World Archaeology, 4 (4) : 244 - 253.

YESNER, D. R. (1977)
"Resource diversity and population stability among hunter-gatherers",
Western Canadian Journal of Anthropology, 7 : 18 - 59.

ZVELEBIL, M. (1984)
"Clues to recent human evolution from specialized technologies?"
Nature, 307 : 314 - 315.

APPENDIX 1.

DATE LIST FOR THE MESOLITHIC

SITE	(b.c.) C14	LAB.NO.	NOTES
THATCHAM 3	8415 ± 170	Q-659	Charcoal from hearth
" " 3	8080 ± 170	Q-658	" " "
" " 5	7890 ± 160	Q-651	Wood from lowest artefact level
" " 5	7830 ± 200	Q-677	Wood from same level as birch-bark roll
" " 5	7720 ± 160	Q-650	Wood - same level as Q-677
" " 5	7530 ± 160	Q-652	Wood - within occupation sequence
" " 2	6140 ± 180	BM-65	Contaminated context ?
LOMINOT 3	7610 ± 350	Q-1187	Charcoal
STAR CARR	7538 ± 350	C-353	Wood from platform
" "	7607 ± 210	Q-14	" " "
MONEY HOWE 1	7480 ± 390	Q-1560	Charcoal
WAYSTONE EDGE	7446 ± 210	Q-1300	Charcoal
MARSH BENHAM	7350 ± 150	Q-1129	Charcoal
WARCOCK HILL STH.	7260 ± 340	Q-1185	Charcoal
OAKHANGER 7	4430 ± 115	F-68	Charcoal, phase 1/2, contaminated?
" " 7	4350 ± 110	F-67	Burnt hazel shells, phase 2, contaminated?
" " 7	7275 ± 200	Q-1489	Burnt hazel shells, phase 2
" " 7	7150 ± 200	Q-1491	Charcoal, phase 2
" " 7	7090 ± 160	Q-1493	Charcoal, phase 2
" " 7	7045 ± 200	Q-1490	Charcoal, phase 2
" " 7	7025 ± 200	Q-1492	Charcoal, phase 2
" " 7	6935 ± 165	Q-1494	Charcoal + Burnt hazel shell
WETTON MILL	6897 ± 210	Q-1127	

GREENHAM	6829 ± 110	Q-973	Red Deer bone collagen
FILPOKE BEACON	6810 ± 140	Q-1474	Burnt hazel shell
RHUDDLAN E	6789 ± 86	BM-691	Charcoal
ABERFFRAW	6640 ± 90	HAR-1194	Charcoal
" "	6690 ± 150	Q-1385	Charcoal
WARCOCK HILL 3	6660 ± 110	Q-110	Charcoal
KINLOCH, RHUM	6640 ± 95	GU-1873	Charcoal
" " "	6565 ± 150	GU-1874	Charcoal
" " "	5975 ± 65	GU-2039	Charcoal
" " "	6610 ± 75	GU-2040	Charcoal
BROOMHEAD MOOR 5	6623 ± 110	Q-800	Charcoal
WEST HARTLEPOOL	6730 ± 180	BM-81	Antler + 'undiagnostic industry'
" " "	6750 ± 180	BM-80	" "
" " "	6150 ± 180	BM-90	" "
" " "	6160 ± 180	BM-83	" " after treatment
RHUDDLAN M	6598 ± 73	BM-882	Charcoal
STUMP CROSS	6500 ± 310	Q-141	Charcoal (associated with artefacts?)
BROOMHILL	6590 ± 150	Q-1192	Charcoal base of pit 3
" "	6565 ± 150	Q-1528	" " " "
" "	6365 ± 150	Q-1383	" " " "
" "	5800 ± 120	Q-1460	Charcoal top fill of pit 3
" "	5270 ± 120	Q-1191	Charcoal over pit 3
" "	4585 ± 125	Q-1128	Charcoal from pit 2
SALTERS BROOK	6400 ± 110 (?)	I-7110	

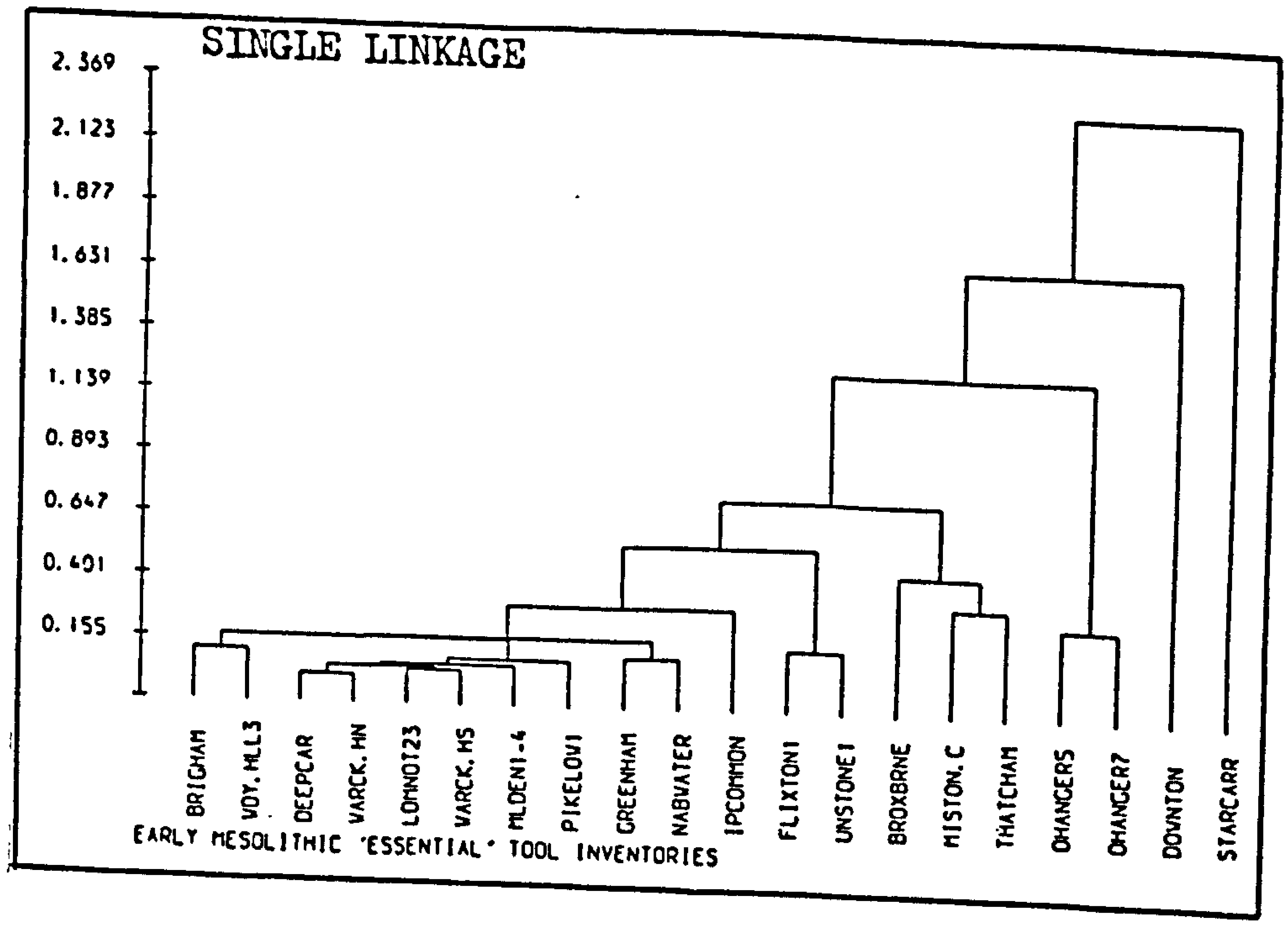
LUSSA WOOD 1	6244 ± 160	SRR-160	Charcoal
" " "	6013 ± 200	SRR-159	Charcoal
ICKORNSHAW MOOR	6150 ± 150	Q-707	Burnt hazel shell
MORTON TAYPORT A	6100 ± 255	NZ-1191	Charcoal from T46 (occ. 1-6)
" " " " A	5380 ± 200	NZ-1302	Composite charcoal sample from T43/44/46.
" " " " A	4840 ± 150	NZ-1192	Composite charcoal sample from T47/55/56.
" " " " A	4450 ± 125	NZ-1193	Charcoal from T53 hearth.
" " " " A	4500 ± 80	Q-989	Charcoal from T53 hearth.
" " " " A	4785 ± 180	Q-948	Composite charcoal sample from T43/44.
" " " " A	4350 ± 150	GaK-2404	Charcoal from T42
MORTON TAYPORT B	4432 ± 120	Q-981	Charcoal from lower midden
" " " " B	4197 ± 90	Q-988	Charcoal from lower midden
" " " " B	4165 ± 110	Q-928	Charcoal from upper midden
NORTH CARN	5464 ± 80	SRR-161	Charcoal
PEACOCK'S FARM	5650 ± 150	Q-587	Peat from approx. same level as industry.
DEAN CLOUGH 1	5645 ± 140	Q-1188	Charcoal
RISHWORTH DRAIN	5600 ± 210	Q-1166	Charcoal
ESKMEALS 1	5430 ± 370	Q-1356	Charcoal
" " "	4802 ± 156	BM-1216	Charcoal
BRENIG VALLEY 40	5700 ± 80	HAR-656	Charcoal from context not directly assoc. with Mesolithic flintwork.
" " " " 53	5240 ± 100	?	Charcoal from pit 19 + flints
" " " " 53	5350 ± 100	?	Charcoal from pit 19 + flints

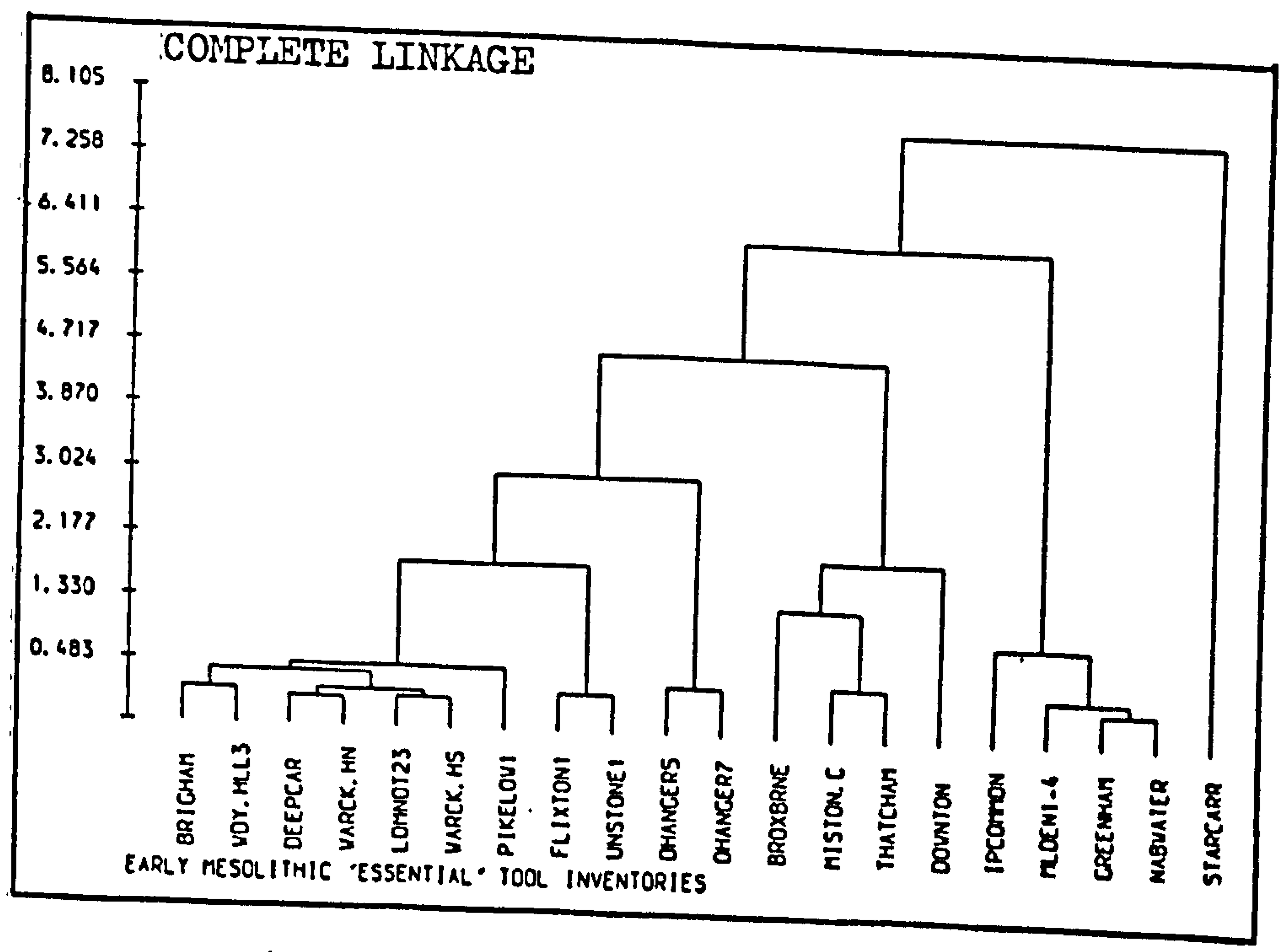
CASTLE STREET, INVERNESS.	5325 ± 235	GU-1376	Charcoal
CHERHILL	5280 ± 140	BM-447	Bone overlying flints
LISMORE FIELDS, BUXTON.	5220 ± 80	HAR-6500	Charcoal
HERMITAGE	4850 ± 100	Q-1311	Charcoal from spit B
" "	4970 ± 110	Q-1312	Charcoal from spit C
" "	5155 ± 70	Q-1562	Charcoal from spit D
CULVER WELL	5151 ± 97	BM-960	Charcoal from hearth on surface under midden.
" " "	5200 ± 135	BM-473	Charcoal from basal midden
" " "	5400 ± 640	OXTL-501bm	Thermoluminescence date on burnt limestone
WESTWARD HO!	5005 ± 140	Q-1211	Burnt Oak
" " "	4860 ± 140	Q-1212	Bone (Aurochs)
BLASHENWELL	4500 ± 150	BM-89	Bone collagen
" " "	3800 ± 140	BM-1258	Bone collagen
THORPE COMMON	4483 ± 130	Q-1116	Charcoal
" " " "	3730 ± 150	Q-1118	Red deer bone above Q-1116.
WAWCOTT 3	4170 ± 134	BM-767	Charcoal
MARCH HILL 2	4076 ± 220	Q-1188	Charcoal
" " " "	3900 ± 80	Q-788	Charcoal
INVERAVON	4060 ± 180	Gx-2331	Charcoal
" "	4005 ± 180	Gx-2334	Charcoal
BARSALLOCH	4050 ± 110	GaK-1601	Charcoal from hearth
FRESHWATER WEST	4010 ± 120	Q-530	Peat assoc. with industry (?)
ROCHER MOSS STH 2	3880 ± 100	Q-1190	Charcoal

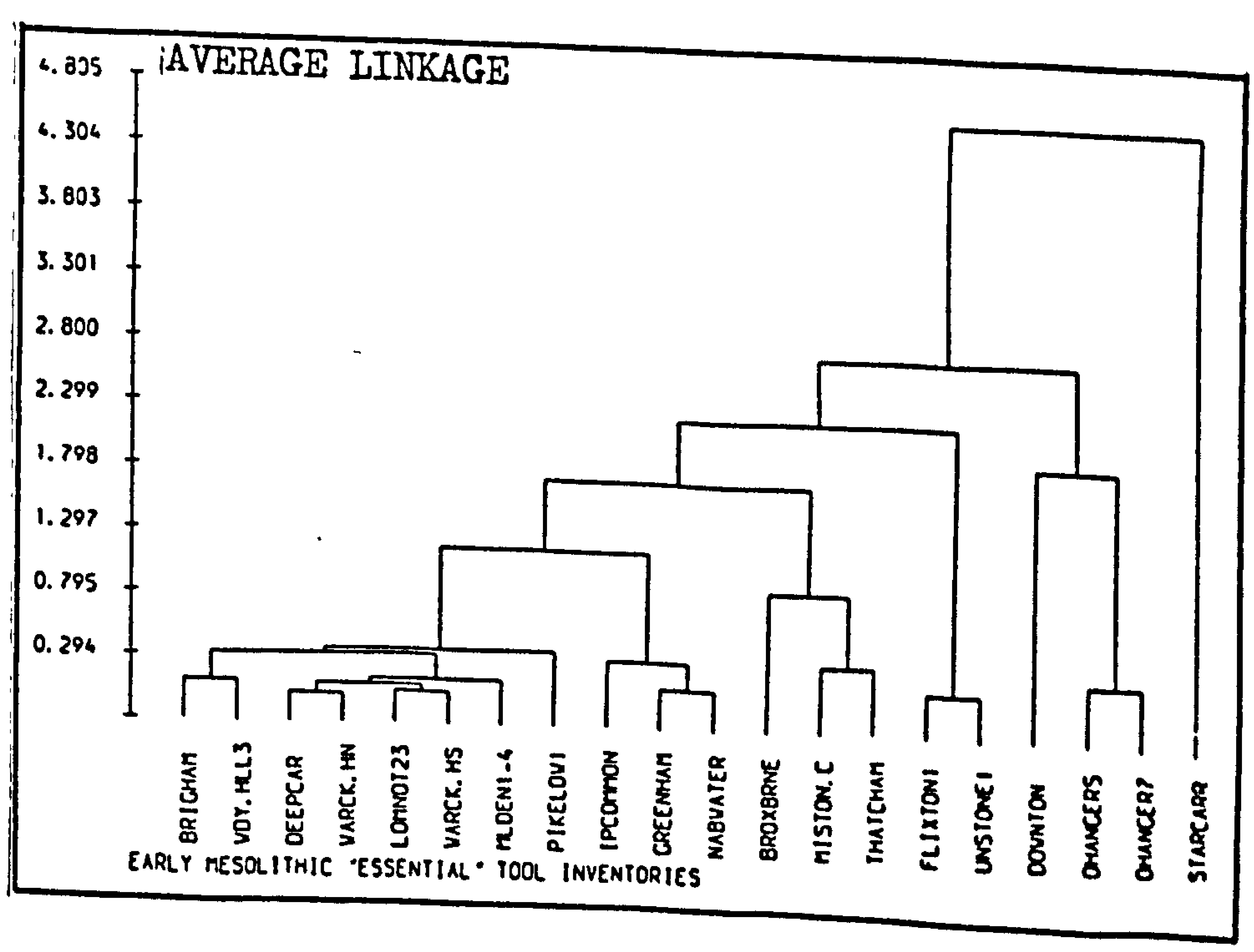
WAKEFORD'S COPSE	3730 ± 120	HAR-233	Charcoal
HIGH ROCKS F	3710 ± 150	BM-40	Charcoal from layer 2
" " "	3780 ± 150	BM-91	Charcoal from layer 2
MUIRTOWN, INVERNESS.	3685 ± 65	GU-1473	Charcoal from hearth at base of midden.
WAWCOTT FARM	3310 ± 130	BM-449	Wood in pit, association ?
LOMINOT 4	3660 ± 120	Q-1189	Charcoal
DUNFORD BRIDGE B	3430 ± 80	Q-799	Charcoal
C-N-G 2	3200 ± 380	BIRM-346	Charcoal from upper shell midden
" "	3500 ± 140	BIRM-347	Charcoal from basal shell midden
" "	3900 ± 310	BIRM-348a	Inner fraction of limpet shell - same level as BIRM-347 - too old due to hard water error
" "	3770 ± 140	BIRM-348b	Mid fraction of limpet shell - same level as BIRM-347 - too old due to hard water error
" "	3620 ± 140	BIRM-348c	Outer fraction of limpet shell - same level as BIRM-347 -too old due to hard water error
CNOC SLIGEACH	3065 ± 210	Gx-1903	Oyster shell
" " "	3476 ± 159	BM-670	Charcoal
" " "	3805 ± 180	Gx-1904	Bone
CNOC COIG	3545 ± 75	Q-1351	Charcoal from upper midden
" "	3480 ± 130	Q-1352	Charcoal from upper midden
" "	3695 ± 80	Q-1353	Charcoal from lower midden
" "	3585 ± 140	Q-1354	Charcoal from lower midden
LUSSA RIVER	2670 ± 140	BM-556	Charcoal
" "	2250 ± 100	BM-555	Charcoal

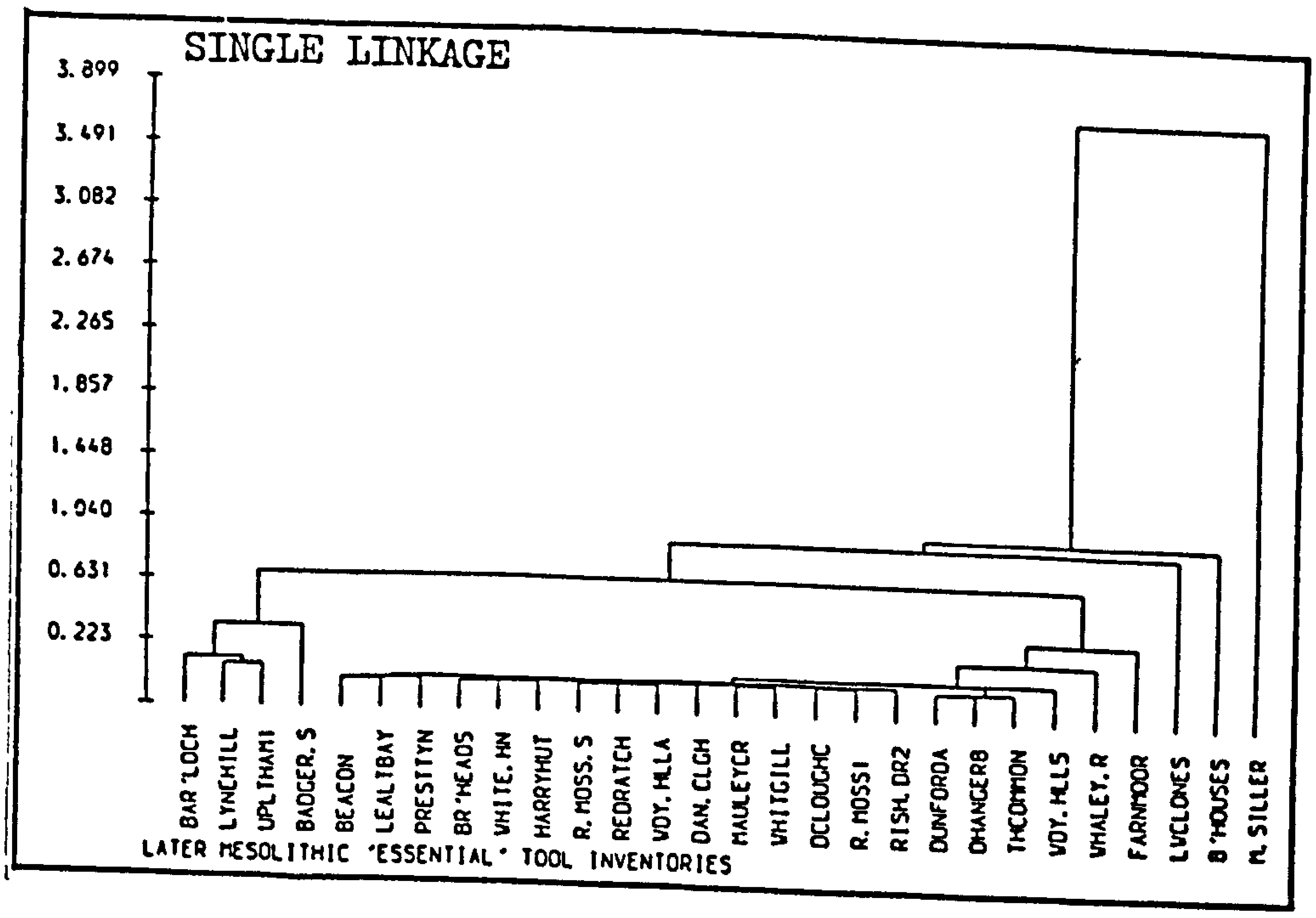
APPENDIX 2.

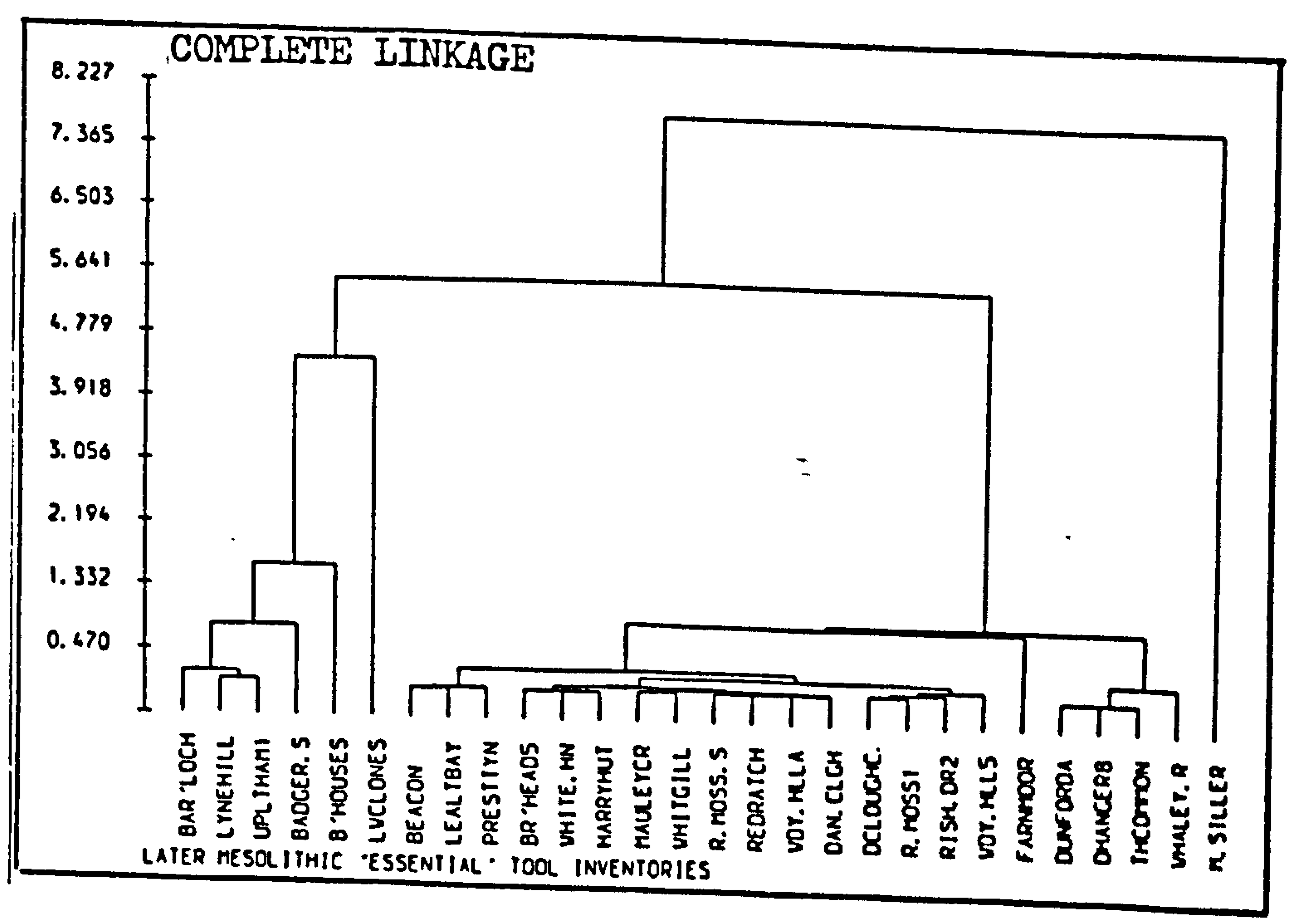
DENDOGRAMS FOR SINGLE, COMPLETE AND AVERAGE LINKAGE CLUSTER ANALYSES OF EARLIER AND LATER MESOLITHIC ASSEMBLAGES.

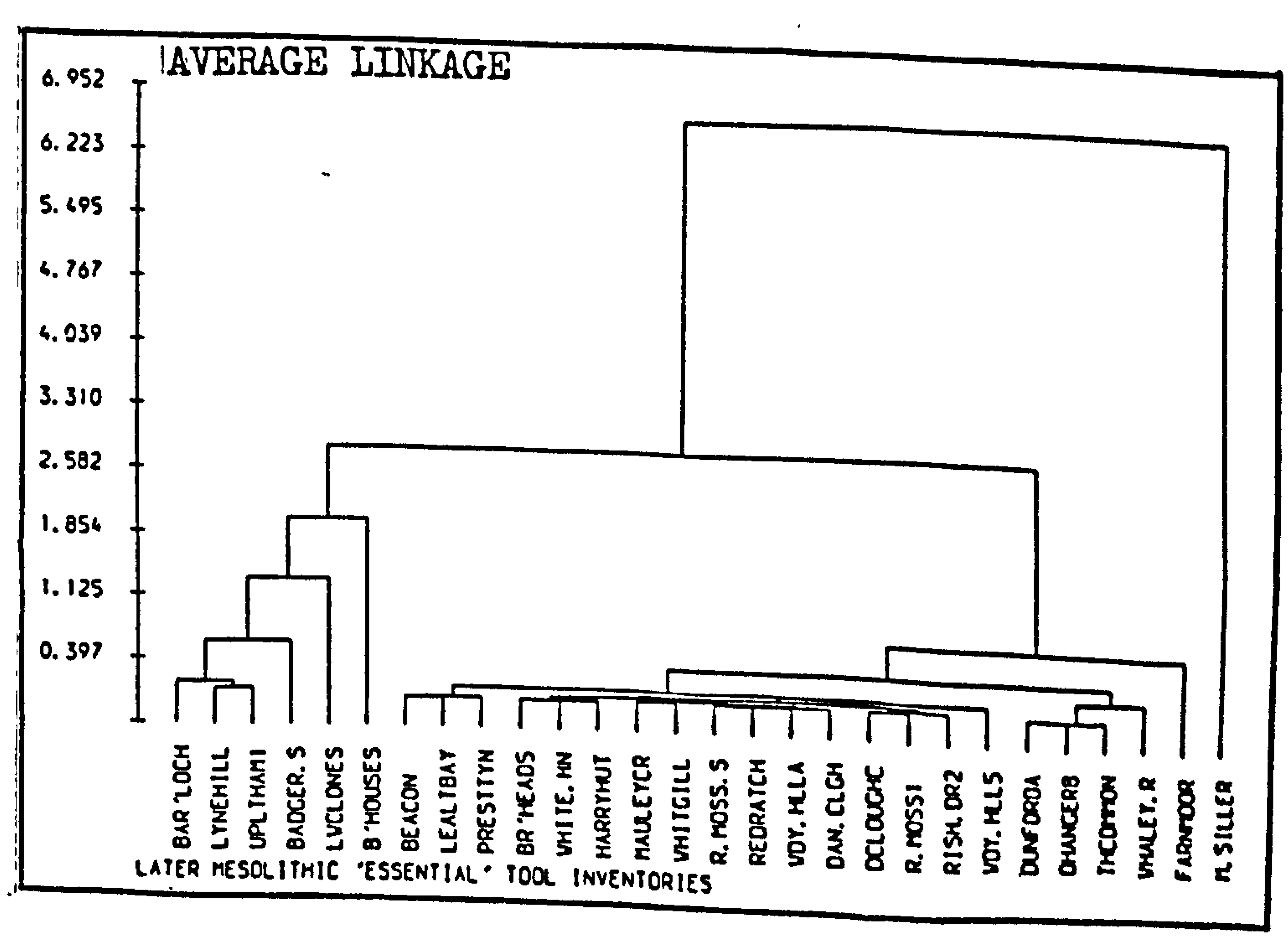

SINGLE LINKAGE
2.369
2.123
1.877
1.631
1.385
1.139
0.893
0.647
0.401
0.155
BRIGHAM
VDY.HLL3
DEEPCAR
VARCK.HN
LOMNOT23
VARCK.HS
MLDEN1-4
PIKELOV1
GREENHAM
NABWATER
IPCOMMON
FLIXTON1
UNSTONE1
BROXBRNE
MISTON.C
THATCHAM
OHANGERS
OHANGER7
DOWNTON
STARCARR
EARLY MESOLITHIC 'ESSENTIAL' TOOL INVENTORIES


COMPLETE LINKAGE
8.105
7.258
6.411
5.564
4.717
3.870
3.024
2.177
1.330
0.483
BRIGHAM
VDY.HLL3
DEEPCAR
VARCK.HN
LOMNOT23
VARCK.HS
PIKELOV1
FLIXTON1
UNSTONE1
OHANGERS
OHANGER7
BROXBRNE
MISTON.C
THATCHAM
DOWNTON
IPCOMMON
MLDEN1-4
GREENHAM
NABWATER
STARCARR
EARLY MESOLITHIC 'ESSENTIAL' TOOL INVENTORIES


AVERAGE LINKAGE
4.805
4.304
3.803
3.301
2.800
2.299
1.798
1.297
0.795
0.294
BRIGHAM
VDY.HLL3
DEEPCAR
VARCK.HN
LOMNOT23
VARCK.HS
MLDEN1-4
PIKELOV1
IPCOMMON
GREENHAM
NABWATER
BROXBRNE
MISTON.C
THATCHAM
FLIXTON1
UNSTONE1
DOWNTON
OHANGERS
OHANGER7
STARCARR
EARLY MESOLITHIC 'ESSENTIAL' TOOL INVENTORIES


SINGLE LINKAGE
3.899
3.491
3.082
2.674
2.265
1.857
1.448
1.040
0.631
0.223
BAR'LOCH
LYNEHILL
UPLTHAM1
BADGER.S
BEACON
LEALTBAY
PRESTTYN
BR'HEADS
WHITE.HN
HARRYHUT
R.MOSS.S
REDRATCH
VDY.HLLA
DAN.CLGH
MAULEYCR
WHITGILL
DCLOUGHC
R.MOSS1
RISH.DR2
DUNFORDA
DHANGER8
THCOMMON
VDY.HLLS
WHALEY.R
FARMOOR
LWCLONES
B'HOUSES
M.SILLER
LATER MESOLITHIC 'ESSENTIAL' TOOL INVENTORIES


COMPLETE LINKAGE
8.227
7.365
6.503
5.641
4.779
3.918
3.056
2.194
1.332
0.470
BAR'LOCH
LYNEHILL
UPLTHAM1
BADGER.S
B'HOUSES
LWCLONES
BEACON
LEALTBAY
PRESTTYN
BR'HEADS
WHITE.HN
HARRYHUT
MAULEYCR
WHITGILL
R.MOSS.S
REDRATCH
VDY.HLLA
DAN.CLGH
DCLOUGHC
R.MOSS1
RISH.DR2
VDY.HLLS
FARMOOR
DUNFORDA
DHANGER8
THCOMMON
WHALEY.R
M.SILLER
LATER MESOLITHIC 'ESSENTIAL' TOOL INVENTORIES


AVERAGE LINKAGE
6.952
6.223
5.495
4.767
4.039
3.310
2.582
1.854
1.125
0.397
BAR'LOCH
LYNEHILL
UPLTHAM1
BADGER.S
LWCLONES
B'HOUSES
BEACON
LEALTBAY
PRESTTYN
BR'HEADS
WHITE.HN
HARRYHUT
MAULEYCR
WHITGILL
R.MOSS.S
REDRATCH
VDY.HLLA
DAN.CLGH
DCLOUGHC
R.MOSS1
RISH.DR2
VDY.HLLS
DUNFORDA
DHANGER8
THCOMMON
WHALEY.R
FARMOOR
M.SILLER
LATER MESOLITHIC 'ESSENTIAL' TOOL INVENTORIES

APPENDIX 3.

EXAMPLES OF FLAKE/BLADE DATA
AND CORE DATA SHEETS WITH
NOTES ON THE VARIABLES.

I) Flake/blade data sheet variables

Material - Raw material type (both flakes and blades)

Size

l. - length (mm) (samples of complete flakes and blades)

b. - breadth (mm) (both flakes and blades)

th. - thickness (mm) (both flakes and blades)

wt. - weight (gm) (both flakes and blades)

Ridges - number of ridges (blades only)

bl.seg. - segment of blade i.e. proximal, mid-section or distal

Platform (samples of blades and flakes)

l. - length (measured parallel to core face)

b. - breadth (measured at right-angles to core face)

prep. - signs of platform strengthening (presence/absence)

Bulb (samples of flakes and blades)

l. -length (measured at right-angles to platform)

h. -height (measured as maximum height of bulb above ventral surface)

Cortex - primary, secondary or tertiary

Prof. - profile (blades only - triangular, trapezoidal etc.)

Comments - any additional comments

Site...............

Proven ance..............

FLAKE/BLADE ANALYSIS DATA

A.M.MYERS 1980

		-----SIZE---------						---PLATFORM---			-BULB-				
UNIT No.	material.	l.	b.	th.	wt.	ridges	bl.seg.	l.	b.	prep.	l.	h.	cortex	prof.	comments.

2) Core data sheet variables

Material - raw material type

max.H - maximum height measured parallel to flake/blade removal

max.W - maximum width measured as right-angle to max.H

weight - weight in grams

Platform

no. - number of platforms

direction - number of distinct directions for flake/blade removals

radius - proportion of mass employed for flake/blade production

Blade scars

no. - number of blade scars

w. - blade scar widths

l. - blade scar lengths

fractures - presence/absence of hinges/step fractures/inclusions on worked faces

comment - any additional comments

site...............

proven ance...............

CORE ANALYSIS DATA

A.M.MYERS 1980

no.	material.	max.H.	max.W.	weight.	--Platform----- no.	direction.	radius.	-Blade scars- no.	W.	L.	fractures	comment