ARCHAEOLOGY OF THE MOUND SPRING CAMPSITES NEAR LAKE EYRE IN SOUTH AUSTRALIA

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I certify that this thesis is based solely on my own research, except where otherwise acknowledged.

ABSTRACT

This study examines the variability of the stone assemblages at the mound springs campsites in South Australia.

The research area is part of the tribal territories of Arabana and Diyari people. It comprises a network of mound springs stretching for about 200 km along the south and southwest shores of Lake Eyre. These mound springs were vital for permanent occupation of this arid region in late prehistory and in the post contact period. Large campsites located near the major springs attest to the prehistoric occupation of the area. Historical accounts reveal that this occupation was abruptly terminated in early 1860's.

Although environment and chronology are uniform for all the mound spring sites the assemblages are distinctly different. They vary in the proportions of lithic materials, tool types, and artefact size. Inter-site variability is prominent while intra-site variation is minimal. The research is focused on this fact as it provides an important clue to the nature of springs occupation.

It is demonstrated that the variability of the mound spring campsites reflects different tactics of use and economy of lithic materials at each site. These tactics were influenced by: a) availability of different lithic materials and b) different demands for processing organic materials.

It is argued that assemblage patterning is sensitive to local circumstances, and affected by quantity and quality of resources at each site. Consequently the variability between assemblages reflects the overall organisation and strategy of land use.

This study attempts not merely to reconstruct human behaviour at each site but rather to understand how this behaviour was organised on the strategic level. This level of organisation is best represented by the differential use of sites within a common settlement system. Organisation such as this suggests consistent links between groups of people in the mound springs area throughout the last thousand years.

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CHAPTER I
INTRODUCTION: PROBLEM AND RESEARCH QUESTION

1. Introduction

This research is focused on the group of archaeological sites located at the network of mound (artesian) springs[1] near Lake Eyre in South Australia. These sites share many features in common. They are all dense surface scatters of stone artefacts characterised by the same types of tools (eg. backed blades, tulas, thumb nail scrapers) associated with the late Holocene. All sites are located in the same environmental setting and within an hour's walking distance from one another. All of them are dense habitation sites, indicating many, if not thousands, of occupation episodes.

External factors including site location, proximity to each other, and narrow chronological framework (late Holocene) are similar for all of the mound spring sites. Yet, the stone assemblages are all distinctively different. This difference is expressed by variable relative frequencies in a) types of raw material; b) size of artefacts, and; c) tool categories.

The reasonable expectation that all mound spring sites should be similar is not met by reality. This conflict between expectation and reality is an ideal example of Binford's surprise discovery, '...one that challenges our expectations about the past itself' (Binford 1972:111).

The research question formulated in this study is to explore and explain the variability of the mound spring sites.

I attempt not merely to reconstruct human behaviour but rather to understand how this behaviour was organised within a

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[1]. Term 'mound springs' refers to the network of natural outlets of water from the Great Artyesian Basin. These artesian springs are particularly numerous and prominent in the central-north part of South Australia, where the edge of the Great Artesian Basin comes close to the ground surface and hydrostatic pressure causes water to flow. See Figure 1 for the location of the mound springs area.

broader life strategy system. In this framework, behaviours, the glimpses of specific activities that can be inferred from the archaeological evidence, document the organisation of community life on the strategic level. I argue that this level of organisation is best represented by the different use of sites within a common settlement system. Although on-site activities were integrated into a support system that can be described as camping life, in order to provide for the same basic human needs, activities were modified in accordance with the site's immediate environment, and consequently specific activities vary between sites. These variations are most clearly demonstrated by different modes of supply, treatment, use and discard of several types of stone material. Nevertheless it is also inferred that the use of stone artefacts varied in accordance with the use of highly localised resources, and that different needs existed for processing organic materials.

2. Research problem

The quantity of archaeological material deposited at the mound springs, impressive by any standard, suggests that the sites were occupied many times and that there must have been a compelling environmental reason to focus the occupation at the springs. While it is easy to understand that rich archaeological deposits accumulated near the springs (Hughes and Lampert 1985), it is far more intriguing to discover that within the bounds of similar tool types the assemblages are distinctively different. In terms of common logic, a tool widely used in archaeological practice, these two facts seem to contradict one another.

If the assemblages were poor, their variability would be easily attributed to incidents separated by time, seasons, and chance factors governing variation of activities. In fact in such circumstances archaeologists are inclined to look for similarities, understanding that variability may be nothing but 'noise' generated by the chance factor.

However, the mound spring assemblages are rich, suggesting that the sites were occupied in a more systematic and repetitive manner by the local population. The movement of people within the area and the dense accumulation of discard resulting from many different episodes of human activity should work towards averaging out the variation between assemblages. Yet the mound spring sites are all distinctively different.

Devoid of stratigraphic context and ostensibly related to the youngest phase of prehistory, the mound spring sites prompted the search for a different formula of archaeological inquiry. It became obvious that some questions deeply entrenched in traditional, chronology-oriented, and eminently coarse-grained archaeological evidence cannot be applied to the mound spring assemblages. Questions such as chronological stages of site occupation or broad cultural changes through time appeared of little relevance.

Instead, the abundance of evidence, complexity, and diversity within an almost synchronic plane presented themselves as the major features of the material record. Consequently the mound springs display characteristics to which archaeologists are little accustomed in common practice with greater chronological depth and far coarser grains of evidence. It appears that my surprise discovery illustrates the discord between expectations and the scale of resolution and that it also challenges the paradigm within which archaeologists traditionally explain variability (eg. Bordes and Sonneville-Bordes 1970; Collins 1969, 1970; Mellars 1970; Rolland 1981; Otte and Keeley 1990).

3. Thesis and its theoretical framework

Although variability is an intrinsic feature of empirical evidence it is not often explicitly focused in archaeological studies (Jones et al. 1989; compare Clegg 1977; O'Connell 1977; Cane 1984; Witter 1992a; Pardoe 1991). The main topics in Australian prehistory are rather formulated as events, for example initial colonisation, extinction of megafauna, and the late Holocene intensification (Allen 1989; Jones 1989; Lourandos

1985; White and O'Connell 1982). Focus on variability is different in emphasis, stressing the exploration of evidence rather than the examination of specific theories or assumptions. Therefore the formulation of thesis must be strongly influenced by the selection of temporal and spatial frameworks. For example a broad chronological perspective would require consideration of significant changes through time; a narrow spatial framework confined to one site would direct attention to the range of activities and their spatial organisation within a site area.

The area of this study is big enough to encompass a large part of the mound springs settlement system (200 km long) within a uniform environmental setting. A chronology is restricted to the last 1,000 years, rendering changes through time invisible or extremely dificult to detect in surface stone assemblages.[2]

Consequently the spatio-temporal framework indicates the level on which the cause of sites' variability should be sought. This variability cannot be attributed to major climatic changes or a succession of completely different cultural traditions (eg. core tool and scraper versus small tool tradition); it cannot be accounted for by different environmental regions or cultural provinces in space. This framework suggests that the causes of variability must be entrenched in the local environmental conditions and local human population.

In order to establish a theoretical frame of reference and also to reconcile any presumed conflict between environmental and social determinants of human behaviour I adopted a concept of life strategy (Rapoport 1990), similar to Binford's 'organisation of human behaviour' (1987c; also Chisholm 1993). The 'life strategy' refers to the fact that local populations of human as well as many animal species develop specific behavioural schemes. This can be recognised in the fields of subsistence, social interactions, and economy. While subsistence and social schemes

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[2]. If changes occured in this narrow time-frame they must have been minor with little impact on the structure of assemblages. Significant changes would cause averaging out inter-site variability, increasing intra-site variation, and alter the coherence of assemblages. These points will be examined later (chapters V, VI, and VIII).

can be found among people and animals (eg. killer whales, chimpanzees), economic schemes involving degree of rationalisation and planing are more specificly human.

The subsistence and economic schemes are largely developed in response to environmental constraints and by the nature of related activities may be directly reflected in archaeological records. The social behavioural schemes are less influenced by environment and more responsive to traditional and current social conditions. They can be reflected by symbols and other means of interaction between individuals, and therefore are far less visible in archaeological records. Consequently archaeology is better equipped to study subsistence and economy rather than the social organisation of past societies. This may be the main reason why social entities largely defined by language, social customs, and ethnic identity (eg. tribes) cannot be identified in archaeology. On the other hand a population defined by common subsistence and economy may be visible through archaeological records.

It must be recognised however that subsistence and economic strategies are responsive to environmental and social conditions; also they have the power to change both natural surroundings and social order. Therefore subsistence/economy encompass some aspects of social life. However in archaeological records it is reflected on very general level, potentially casting light on the strategic organisation of the community rather than on specific social arrangements. The life strategy refers to this organisational aspect of local populations.

My thesis is formulated within such a framework, and it claims that the variability of the mound spring sites can be accounted for by two factors: a) uneven spatial distribution of resources: different quantities and qualities of resources available at different sites, and; b) the different subsistence and economy tactics which were allocated to particular sites in response.

4. The mound springs as surface sites

The main entities of this study are the archaeological sites associated with the mound spring network. The specific qualities of these sites have had a strong influence on the formulation of the research problem and its resolution. For this reason it is important that these entities are characterised within a broader context of archaeological site concept.

The mound springs represent the special category of surface sites. These can be provisionally defined by two characteristics: a) the largest proportion of stone artefacts is found on the surface (compare Mitchell 1949:4), and; b) there is a strong integrity[3] of the assemblages. These characteristics are explored in this study (see chapters VI and V), providing some important clues to the sites' depositional history and chronology, as well as the intensity and nature of human activities.

Firstly I will discuss some research problems and solutions associated with the surface sites in general, to link and to contrast the mound spring sites with the broader archaeological context. By doing so I will follow two general arguments: a) the current state of an archaeological site is valid evidence from which to infer about its depositional history, and; b) understanding a site's history is crucial to inferring human behaviour in the past (Binford 1968, 1977, 1981; Schiffer 1972, 1976, 1983, 1987; Wood and Johnson 1978; Stevenson 1991; Stockton 1973; Hughes and Lampert 1977; Colley 1990).

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[3]. 'Integrity' meaning "whole, unimpaired, in good condition" can be recognised on surface sites by several attributes. Immediate inferences can be made from: a) spatial distribution of artefacts; b) their association with features (eg. hearths); c) range of artefact sizes, including very small objects, and; d) condition of landform on which site is located. Detailed study of artefacts, especially technological, conjoin, and spatial analyses can provide additional, more specific evidence of site integrity.

Before defining an archaeological site it is beneficial to consider that archaeological evidence may occur in non-site contexts. Although this non-site material has been known from the pioneering days of archaeology, focus on the site was prevalent until the sixties (eg. Binford 1964; Clarke 1968). Non-site archaeology gained prominence in several survey projects in the USA (Thomas 1975; Dunnell and Dancey 1983; Tainter 1983), was followed elsewhere (Binford 1980; Foley 1981) and subsequently integrated into regional archaeological research (eg. Thomas 1989; Fish and Kowalewski 1990).

For example Foley (1981:158) constructed his definition of a site around the concept of continuous distribution of archaeological material over the area with 'series of concentrations grading out to a dispersed artefact scatter.' A theory is built into this definition by assuming that concentrations, under normal circumstances, would result from human activity being preferentially performed at 'spatial foci.' Foley suggests that temporally extended occupation of the area would result in density increase of non-site material and concentrations could be blurred.

A similar point of departure is adopted by Plog <u>et al</u>. (1978:389) for whom 'a site is a discrete and potentially interpretable locus of cultural materials;' where a) discrete means spatially bounded and marked by at least relative changes in artefact densities; b) interpretable means that material is of sufficient quantity and quality to infer about behaviour that occurred at a locus, and; c) cultural materials mean artefacts, ecofacts, and features.

Both definitions assume that the mode of distribution of cultural materials (concentration and dispersion) initially results from human behaviour but it is important to notice that geomorphic processes can transform concentrations into dispersed mode and dispersed materials into concentrations (Foley 1981; Schild 1985). Also it is possible that many such transformations take place before the archaeological material is recorded and recovered, so there is not a single linear process from one state to another. However, it must be clear that the original site structure can only deteriorate with time and can never be restored.

While in Foley's definition (1981) the question of site integrity is opened, Plog et al. (1978) require that at least some level of integrity is preserved. If the concentration of archaeological materials was formed by geomorphic process alone, in a strict sense it may not be interpretable in terms of past human behaviour. In this extreme case even 'sufficient' quantity and quality of cultural material is meaningless and would require that such 'sites' are excluded from definition.

This brief comment on site definition provides a convenient background for discussing surface sites. They are commonly characterised by a significant portion of archaeological material being exposed on the land surface (Thomas 1973, 1989; Dunnell 1985; Lewarch and O'Brien 1981). Such partial exposure always was and still is, a valuable indication of an archaeological site buried underground and is widely used in various survey procedures to locate and record the archaeological evidence in the region (Thomas 1989). Also it is often expected that such buried sites would preserve a higher degree of integrity and pattern resulting from human behaviour than can be expected from the material scattered on the surface. Thus 'the surface is informative to the extent that it reflects what is underground' (Redman 1987:250).

In the pioneering days of archaeology surface material was often collected as a representation of artefacts from the site without regard to the spatial distribution, density and association of objects within the buried part of the site (eg. Howchin 1934; Mitchell 1949). It was only in the last few decades that sampling-conscious archaeologists decided to explore whether surface scatters may or may not display any pattern related to the structure of buried material beneath the surface. In their textbook Hole and Heizer (1969:140) took the position that surface material is no more 'than a rough guide to a site's contents.' Other archaeologists believed that surface material would reflect the structure of deposits beneath the surface (eg. Hill 1968; Redman and Watson 1970). A persuasive case for such associations was presented by Gaffney and Gaffney (1988) who demonstrated that ceramic fragments scattered within an intensely disturbed ploughing zone still reflect the pattern of the settlement remains beneath the surface.

While the growing awareness of a structure in the surface material was centred around the concept that surface scatter was an extension of the buried site, slowly emerging on the surface, quite a different concept has been explored within ethnoarchaeology. Here surface scatters of artefacts become the sole material evidence directly related to the activities of indigenous communities in the 'present past.' Spatial distribution of artefacts and site structure in general acquired a whole new meaning where the spatial pattern itself can be explained in terms of organisation of human activities (eg. Kent 1991; Cane 1984; O'Connell 1987; Binford 1987c). Although the ethnoarchaeological experience cannot be directly applied to prehistoric sites it provides a strong case for significance of patterns in scatters of surface material. The ethnoarchaeological exploration also demonstrates that there are archaeological sites, consisting exclusively of material on the ground surface and that this material may display integrity equal to or even greater than many stratified deposits.

In order to assess the scientific value of the surface material it is useful to separate patterns of human origin from the pattern produced by the natural agents (eg. Schiffer 1976, 1987). Since archaeologists rejected the idea that material evidence is a 'frozen past' there has been a rapidly growing body of research attempting to explore the more universal principals of distribution of artefactual material caused by natural agents on one hand (eg. Rick 1976; Baker 1978; Gifford 1978; Schild 1985; Nash and Petraglia 1987; Schick 1986, 1987), and human activities on the other (eg. Schiffer 1972; Binford 1977, 1987c; Kent 1984, 1987a; Colley 1990). This research demonstrates that archaeological materials are subject to many processes some of which are transformations: a) from surface to stratified position; b) from stratified to surface context; c) from humanly-made configuration to geomorphic patterns; d) from concentrated to dispersed mode, and; e) from high integrity to low integrity. Binford (1987b) emphasises that initially all sites were exclusively surface deposits, and many of them must been greatly transformed and severely disturbed before they were incorporated into a stratified context. While some transformations can be reversed (eg. from surface to stratified and back again), some show consistent trends (eg. from concentration to dispersal), and some can only go one direction (eg. from high to low integrity, from humanly-made to geomorphic pattern[4]).

In general, the patterns of human activities are being diminished in time and there is a constant reduction of evidence in their quantity and quality (Thomas 1989:431). It is obvious that surface sites provide the best evidence for observations on many aspects of sites' dynamic (post-depositional prosesses), since the large body of material is readily accessible and the process of various transformations is relatively rapid. Also it is obvious that surface sites tend to be most readily disturbed and destroyed by both natural forces and human activities.

In this context, general inferences about the mound spring sites can be made. Three of the sites' characteristics are especially significant for inferences regarding their depositional history.

1) Preservation of facilities. Many fireplaces, some superbly preserved, can be found on these sites. In Foley's view (1981;162) camp facilities are the first to be destroyed, and if they are well preserved on the land surface one may expect the sites to be relatively young. To infer an age from such a characteristic alone is extremely difficult, however some measurable processes of sites' destruction and its speed (see chapters V and VI) suggest that the chronology must be measured in hundreds rather than in thousands of years.

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[4]. This excludes situations where cultural material is re-used by different people, in different times and usually for a purpose quite different from the original function.

2) Preservation of integrity. The stone and bone materials are associated with the fireplaces (high density of artefacts overlap with concentrations of fireplaces), suggesting that the site's facilities and artefactual scatters were not divorced by the process of dispersal and/or re-deposition (compare Stevenson 1991).

3) Rapid process of destruction. The observable evidence of post-depositional processes, working towards disintegration of facilities, sites' integrity and overall dispersal of artefacts is surprisingly swift. Three types of evidence have been identified in this project: a) rapid emigration of artefacts from their original place of deposition due to gravity, wind, and water action; b) rapid deflation and/or displacement of many dunes on which the sites are located, causing dispersal of artefacts and destruction of facilities, and; c) flood destruction visible within the sites located on low, flood-prone position. All these processes operate with considerable speed and sites' degradation can be measured from year to year (some examples are presented in chapter V and VI).

It should be noted that unless there is a short time frame, good preservation and rapid erosion appear to be conflicting features.

In the mound spring sites a majority of artefacts are exposed on the surface. Only a small fraction is sub-surface material and this is not strictly stratified but buried within a thin layer of loose, and often rapidly shifting sand. This is more akin to the situation encountered on ethno-archaeological sites (eg. Gould 1971; Hayden 1979a; Cane 1984; O'Connell 1987; Binford 1987c; Anderson and Robins 1988; Jones and White 1988; Gorecki 1988) and in a practical sense these sites are almost completely exposed on the surface.

This characteristic makes the mound spring sites rare by archaeological standards.[5] Similar levels of exposure are usually associated either with heavily eroded and therefore severely disturbed sites, or with unstratified sites known from ethno-archaeological context. Indeed in the second half of the last century when some indigenous inhabitants were still alive (though forced to relinquish their traditional ways of life), the mound spring sites could have been a valid and interesting target for ethno-archaeological study, similar to these conducted more recenty in Australia (eg. Gould 1971, 1980; Hayden 1979a; Binford 1987c; Cane 1984; Nicholson and Cane 1991).

The juxtaposition of three factors a) nearly complete exposure; b) high degree of sites' integrity, and; c) the speed of destruction, provide persuasive though circumstantial evidence, of the mound spring sites' antiquity. These inferences are supported by a series of radiocarbon dates covering the span of 700 years before contact (Table 2, p.75).

The important implications are:

a) that the mound spring sites represent a narrow chronological framework comparable to the Maoris' occupation of New Zealand (Shawcross 1969) and the wetland sites in the South Alligator River (Jones 1985b);

b) the narrow chronology reinforces the fact that all sites were interdependent entities within a common settlement system, and;

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[5]. In a broad sense the quantity of surface sites left by hunter-gatherers reflects the time period which elapsed after their deposition was interrupted. For example such sites are absent in Europe where the last hunter-gatherers disappeared about 6,000 years ago; can be found in many parts of USA where hunter-gatherers vanished or changed their lifestyle between 500 and 150 years ago; and are very common in Australian arid interior, where indigenous people were forced to abandon their traditional lifestyle only between 1860 (outset of trans-continental explorations) and the early decades of this century.

c) that the episodes of sites' occupation occurred repeatedly year after year, providing both synchronic and diachronic links between different groups and community members. These links, manifested by the common settlement system, are important evidence for learning about the ways of life and their organisation as practiced by the local population.

The obvious consequence of such a narrow chronology and plentiful episodes of human activities conducted within the common settlement system would be a dramatic increase in the resolution of archaeological evidence and a focus on a different scale of observation than that commonly accessible to the archaeologist (eg. Allen 1972; McBryde 1974; Lampert 1981; Schrire 1982; Smith 1988).

5. Research objectives and procedures

The goal of this research is to examine the nature of the mound spring sites variability and its causes. This examination requires several steps in research:

a) specify spatio-temporal framework;
b) define the type of records that will be used;
c) procure relevant evidence;
d) demonstrate variability among the sites in relation to intra-site variability;
e) examine sites' variability through analysis of archaeological evidence, and;
f) explain variability.

These steps are integrated into the four main aims:

1) Descriptive: where spatio-temporal framework of research is established and basic characteristics of environment and archaeological evidence are outlined.

Location of archaeological sites in the arid zone is strongly influenced by the availability of water. Regional geography usually provides a basis for predicting sites' distribution and their character (eg. Jones 1979a; Hughes and

Hiscock 1981; Hughes 1981a, 1981b; Hughes and Lampert 1985; Veth and Hamm 1989; Veth et al. 1990). To provide relevant information the natural environment is described in chapter II, location and nature of sites based on the former studies (Hughes and Lampert 1985; Lampert 1989; Lampert and Hughes 1987, 1988) are provided in chapter III, and a model exploring sites' distribution and its meaning is presented in chapter IV.

Chapters V and VI explore spatial outline of the mound spring sites and their integrity, providing a ground for sampling procedures necessary to acquire evidence of relevant quality and quantity.

2) Methodological: where variability is defined as variable frequencies of raw materials, tools, and artefact size between assemblages. Also it is argued that measurement of these variables provides sufficient ground for demonstrating sites' variability and inferring their different role in common settlement system (chapters VI and VII). I place emphasis on the fact that the settlement system (not separate assemblages) provides the most appropriate framework for explanation of variability (Parsons 1972; Binford 1987c).

Because variability is a matter of degree it must be clearly defined. I recognise that the mound spring assemblages are characterised by inter-site variability and intra-site uniformity (or comparatively insignificant variation). I will examine this proposition within specific data set where:

- inter-site variation is defined only by variable relative frequencies in a) lithic raw materials; b) size of stone artefacts, and; c) stone tool categories between the assemblages, and;
- intra-site uniformity is defined only by even spatial distribution of relative frequencies in a) lithic raw materials; b) size of stone artefacts, and; c) stone tool categories, within the inner site area which preserve significant component of behavioural pattern (in contrast to site's periphery displaying high degree of geomorphic pattern in configuration of artefactual materials) (chapters V and VI).

3) Analytical: where my focus on the artefact size structure is reasoned (chapter VII) and applied to the study of evidence (chapter VIII). It is demonstrated that such an approach provides not only good resolution of variability but also offers a firm ground for its explanation.

I recognise that degree and mode of reduction are two essential factors involved in stone artefacts' manufacture and use (Ahler 1989a, 1989b). Consequently quantification and analysis of artefact size in conjunction with raw material, morphology, and technological traits reveal essential facts about the past activities directly related to stone artefacts. This also helps to infer other activities not directly involved in use of stone artefacts, and above all, some aspects of organisation behind those activities.

4) Explanatory: where inferences are integrated into the framework of life strategy in order to demonstrate causal links between variability and environmental and socio-economic factors (chapters VIII and IX). Also I argue that the combination of life strategy as a theoretical framework and the size-structure of stone assemblages on the analytical level provides the effective means for research into the causes of variability in archaeological records of hunter-gatherers. This approach is compatible with biological and evolutionary research (eg. Chisholm 1993; Dunnell 1978; Rindos 1989; O'Brien and Holland 1990; Pardoe 1991; Witter 1992b) and as such is capable of bridging assumed conflict between social and environmental roots of variation and change. From this perspective prehistory can be seen as more akin to natural history rather than the traditional social sciences (eg. Gellner 1982).

In this study I have approached problems less common in archaeological practice, such as elaborate study of surface sites, very large number of stone artefacts, and a research question centred on variability. Because of this it has been necessary to devise my own research formula rather than borrow existing and proven procedures both on theoretical and analytical levels. Some innovations or search beyond the common procedures are made in three following fields: a) an archaeological sampling of the mound spring assemblages; b) classification of the stone artefacts, and; c) analysis.

A. sampling

The archaeological sampling of the mound springs can be described as exploration and procurement of the quantitative evidence. This evidence is to demonstrate the reality of a number of observations that can be readily made on the surface sites but are far more difficult to demonstrate. Such observations are made in three areas relevant to subject of this study.

The variability of the spring sites is the focus of this research and accordingly the main reason for archaeological sampling is to demonstrate both intra and inter-assemblage variation. This raised the question: How should such sampling be conducted, for it became apparent that random sampling, advocated by common archaeological practice (Binford 1964; Redman 1974, 1987; Mueller 1975a, 1975b; Plog et al. 1978; Thomas 1989), would produce badly distorted evidence (this subject is fully discussed in chapter V). To obtain samples representative for the sites, (the principal requirements of the field exploration), I needed to demonstrate the integrity of samples and their structural congruence with the assemblages. This is achieved by analysis of spatial distribution of material within the sites and distribution of samples. It appears that two general forces can be recognised within the pattern of assemblages: behavioural and natural. Consecquently site's depositional history and taphonomic processes must be understood before a reasonable sampling strategy can be designed.

The problem of sampling is dependent on an ability to distinguish the pattern with a substantial behavioural component from the pattern largely resulting from natural processes (eg. geomorphic). In the case of the mound springs a behavioural pattern is associated with a high rate of deposition, mixed materials from different episodes of occupation, and is largely related to the flat inner site area. The natural pattern exhibits accelerated displacement and sorting of material according to its size, and is most clearly associated with slope and/or site periphery. While these patterns no doubt overlap across the site, it appears that the behavioural pattern (reinforced by multiple site use, 'occupational disturbance', and quantity of artefacts) dominates inner site area.

The main challenge of the field exploration was to understand site dynamics and consequently to determine the sample size and where the units of sampling are positioned. The discovery made at this stage was that both sampling in a random manner and/or in transect across the site produced an unacceptably high component of natural (non-behavioural) pattern. Although such a pattern can be separated, mainly by size-grading, spatial, and topographical analyses, it cannot be accepted as the representative pattern for past human behaviour. It has also been discovered that assemblages display a highly homogenised pattern across the inner site area and, in theory, a small sample taken from the core area provides a good representation of the assemblage. For this reason I focused sampling on the inner, high density site area (chapters V and VI).

B. classification

Classification is a crucial step towards pattern recognition (Rouse 1960; Dunnell 1971, 1986; Binford 1987c; Kent 1987b). However, often it forces certain assumptions and meanings into the assemblage structure. The best example is the stubborn insistence that types of stone tools must, above all, reflect cultural identity (Bordes and Sonneville-Bordes 1970; Mellars 1970; Collins 1970). It is impossible to classify archaeological material without imposing on it certain assumptions and meanings. If this cannot be avoided it may be better to make such assumptions explicit. In my classification I made two assumptions: a) that specific categories of tools are substantially associated with particular function (no matter how broadly defined), and b) that stone artefacts (including tools) result from the process of reduction and therefore size-structure best reflects history of stone material, its treatment, use, and discard.

My definition of stone artefact function is broader than the conventional one (compare Binford and Binford 1966; Binford 1973), where function is basically referred to by a) the manner in which an implement is manipulated such as cutting, adzing, grinding (often inferred from use-wear), and; a) type of material being worked with an implement such as wood, hide, seed (often inferred from use-wear and residue, eg. Keeley 1977; Hayden 1979b; Vaughan 1985; Kamminga 1982; Boot 1986; Fullagar 1988).

While referring to the function of implements I mean not only that specific tool types may have been used to work with different materials (eg. scraper with wood, hammer with stone) and in different methods (eg. carving and knapping respectively) but also that they played different roles (function) in the domain of hardware. For example some implements, such as stone flakes, are easy to make (where only stone is present) and they are readily discarded. Other implements, such as tula flakes, require specific quality material, core size, and elaborate process of manufacture. Consequently tula flakes are made in some quarries, carried around by artisans, maintained for prolonged use, and discarded only after being worn out.

In the archaeological context such roles are more difficult to describe, but often there is enough direct and circumstantial evidence, permitting inference about the modes of tool procurement, durability, maintenance, hafting, use, recycling and discard. The inferences can be made from tool's morphology, size, degree of modification, use-wear, material, and setting of discard. Such examination can best be pursued with the group of tools in the assemblage context rather than by analysing single objects in separation. In this project artefacts are analysed as the type-groups and compared with other groups in and between assemblages.

In short stone artefacts result from a dynamic process of reduction and use, therefore an assemblage is the compressed material evidence of such dynamic processes where the history of its origin is reflected by size, morphology, and relationship between the artefacts. The size of morphologically distinct objects and their relative frequencies are the most evident tracks of a behavioural path adopted for specific activities and site as a whole.

Consequently, in response to the large quantity of material and my concept of stone artefacts, I introduced size-grading analysis as the centrepiece of classification (chapter VII). Every sample and each assemblage is characterised by specific size pattern of debitage. Because stone type influences the material treatment on one hand and its function on the other (Cane 1992), size-grading is done separately within different types of stone. It appears that size-grading provides a very powerful analytical device that goes a long way towards the meaningful explanation of the assemblage patterns (compare Ahler 1989a, 1989b; Henry 1989; Magne 1989).

In addition material is characterised by frequency of tools, cortical flakes, and breakage. It is assumed that tool categories are associated with particular kinds of work. This assumption is supported by the fact that the same categories of tools were observed in their traditional use in the Lake Eyre area during several decades after occupation of the mound spring was abruptly disrupted (Aiston 1928, 1930, 1920-40; Horne and Aiston 1924). Aboriginal use and classification of similar stone tools were also recorded in Western Desert, providing the most persuasive argument for association of tool categories with particular functions (Cane 1984, 1988, 1989, 1992).

C. analysis

Statistical analysis is the main tool used in drawing inferences from quantitative data. Statistical analysis is also a process of reduction where complex data structures can be simplified into a single, often elegant, mathematical or visual expression. This reduction is blissful on the one hand and hazardous on the other, for the vital complexity of data can easily be lost in an attempt to fit too much into a single elegant formula. Such a simplistic solution is well illustrated by monitoring Autralia's current economic plight by measuring the thickness of the Yellow Pages for a few consecutive years (Sydney Morning Herald, 2 November 1992:1). Because of the danger of over-simplification I applied separate statistical analyses to many specific aspects of data structure rather than seeking one grand analytical formula that would encompass, and reduce, all complexity. By breaking my analysis into several different aspects of variability I was able to explore both some obvious clues (eg. association between tool categories and types of stone material) and unforeseen leads (eg. relationship between reduction of stone artefacts, degree of curation, and intensity of occupation).

Although I explored data structure using different statistical analyses (Wright 1989, 1992), it appeared that in most cases a correspondence analysis provided the best and least distorted expression of the structure.[6] In effect I was able to keep the statistical investigation simple with a minimum of technical comment required to explain the results and their meanings.

6. Conclusions

Variation is a matter of degree. Things that are perceived similar in one context and magnitude can be seen as different in other situations and dimensions (eg. Pardoe 1991). Generally, where there is a relative scarcity of records (eg. sites) and attributes (eg. artefacts) archaeologists tend to look for similarities. However, differences are well recognised when a large geographical area (eg. continent) and long chronology is considered. In the narrow spatio-temporal framework, similarity is more commonly expected and sought. Variation is often treated

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[6]. Although correspondence analysis is an effective and simple analytical tool, it is often misunderstood, especially when significance of rare variables is accentuated and common variables depreciated (eg. Shennan 1988:284-286).

as 'noise'. Perceived lack of variation offers little challenge in an historical science such as archaeology. This perceived lack of variation resulted in the long held view that the Australian prehistoric population was extremely conservative and has resisted any changes over an immense length of time. In contrast, within a comparable time frame, European prehistory was punctuated with many abrupt cultural transformations.

The mound spring sites are exceptionally rich deposits of stone artefacts. These sites have many features in common and therefore can be describe as similar (see Hughes and Lampert 1985). However, even if the common features allow the researcher to cluster the mound spring sites in one group, distinct from other sites in and outside of this area, there is unusually high variation within the group. I suggest that our ability to perceive this variation is largely due to the rich data matrix.

The most immediate implication is that the mound spring sites provide a unique opportunity to study variation within one subsistence system. This variation can be seen as a reflection of a fine-tuned life strategy, much more subtle than the relatively crude alterations prompted by seasonal changes. The homogeneous landscape of the mound springs country must have been perceived by prehistoric inhabitants as a patchwork and this subtle diversity was accounted for by the survival strategy in an extremely difficult environment.

Moreover, this strategy of land use was followed faithfully for several hundred years, providing a rare glimpse of the past social system which must be brought in as the factor responsible for consistent transformation of traditional knowledge between groups and down through the generations.

CHAPTER II

LAND: ENVIRONMENTAL SETTING

'This part of the country is very stony and bad'.

John McDouall Stuart 1865:14

1. Introduction

In this chapter environmental evidence for developing a geographical model of occupation of mound springs is outlined. Landforms, climate, flora and fauna of the region are described. The overall picture shows a harsh land where an mean annual rainfall barely fills a schooner beer-glass but evaporation is over three metres. Since records have been kept (1874), seventy out of one hundred years received much less than the average rain, and seven droughts of three to eight years duration were recorded. Summer temperature occasionally climbs to over fifty degrees Celsius; in winter it can drop below freezing point for one hundred nights. Rarely sufficient, rain brings a spasmodic outburst of life and the mass migration of pelicans and cormorants to Lake Eyre, and there is proliferation of life in every pool of water. When the drought strikes, only the most resistant plants such as mulga and large trees can survive; future life of other plants and insects is hidden in seeds and eggs, some able to wait many years for the change of a fortune. Tough reptiles can go for years without water. Some forms have developed sophisticated techniques to combat water depravation and heat. They all reflect an environment which is hostile to nearly all forms of life.

The environmental setting encountered in this study represents a rare extreme for human habitation during both the late Pleistocene and Holocene. The harsh climate, scarcity of water and vegetation, erratic rainfalls and common droughts make up the specific combination of factors affecting the way in which people organised their subsistence and other activities within both the landscape and climatic variation through time. Archaeological material reflects this environmental extreme with dense scatters of artefacts concentrated around artesian springs in the area.

The distribution of geographical features and archaeological material alone offers rich evidence from which several aspects of the past living strategies of foraging people can be deduced. The quality of archaeological material, such as clear distinctions between spring and non-spring sites, and abundance of stone artefacts, suggests that inferences made on such basis are secure.

2. Land of the Lake Eyre region

Lake Eyre is a huge shallow sink with its bottom about 20m below the sea level. Several large rivers such as Cooper, Diamantina and Georgina form a framework of the extensive drainage system. This system stretches far north-west to the MacDonnell Ranges, north up to the boundary of the Gulf Country and north-east to the Central Queensland Tablelands. The south part of the catchment is narrow, with local creeks barely extending to the north Flinders Ranges (Allan 1985; 1990). The area of the Lake Eyre Basin covers 1.3 million square kilometres, that is, equal to the area of the whole Northern Territory. Apart from several ranges bordering fringes of the basin this huge area is filled with thick layers of clastic sediments composed of clay, silt, sand and gravel. In recent geological history these sediments have been subject to massive movements (Wasson 1982; Twidale and Wopfner 1990). With each wet period the immense volume of clastic sediments is being slowly dragged towards the lake. The Channel Country is a spectacular illustration of this process. At the same time the sediments from the dry playa lakes and the flood-plains are being constantly excavated by wind and masses of silt and sand are transported hundreds of miles away. The enormous dune fields such as the Simpson Desert are built by these powerful processes.

The Lake Eyre Basin environment is extremely dynamic. Constructive and destructive forces are not balanced by stabilising factors such as thick vegetation cover, large bodies of water and well entrenched drainage systems. 'This country is all sand and stones, and the sand hills are always shifting, even in the river beds there are miles of sandhill and the water in flood time either found a new bed or washes them away' (Aiston 1920-40, letter of 27/3/1921:7).

3. Mound springs country: geology and landforms

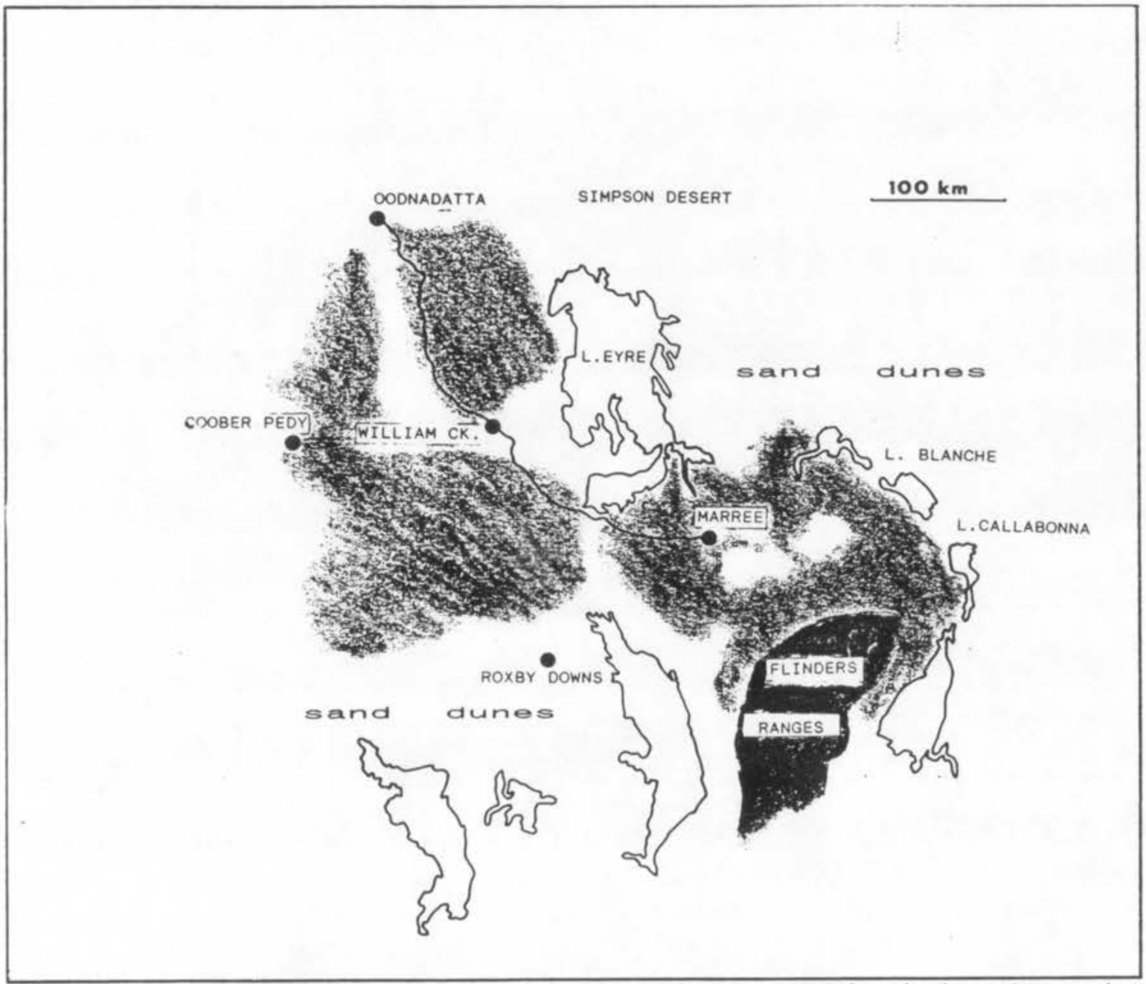

Figure 1. Extensive stony desert (light shading) in the Lake Eyre region. The road from Marree to William Creek follows the chain of mound springs referred to in this study.

The study area is part of a large stony desert extending for 500 kilometres from the lakes Blanche and Callabonna in the east to the opal fields around Coober Pedy in the west. At the south it is bordered by the northern Flinders Ranges and Willouran Ranges, Lake Torrens and dune fields in the Roxby Downs area. At the north it is bordered by Tirari Desert, Lake Eyre and

Warriners Creek. Beyond Warriners Creek there is a large pocket of sand ridges but the same stony desert extends further north, wedged between Great Victoria Desert and Simpson Desert (Fig. 1, p.24).

This monotonous gibber plain is broken by gently undulating landforms, small ridges, low escarpments and mesas (Photo 1). Some of these landforms are still capped with duricrust of Miocene origin with characteristic silcrete deposits, attesting to more stable and wetter condition in the past. Other mesas and small plateaux rising above the plain are covered with Pleistocene limestone and equivalent gypsite crust, preventing softer sediments underneath from rapid erosion. The crust is breaking at the cliff-like edges of such landforms and crumbling down. It is gradually crushed with the hard materials such as silcrete and quartzite, and rounded into the pebbles which pave the large gibber plains. The undulating plains themselves are eroding; abrupt deep gullies are formed by running water. Many ephemeral creeks cut into soft sediments; they can be locally stabilised when mulga shrubs take hold along the creek lines but all larger creeks tend to meander on the low plains with a web of channels which change rapidly during major floods. A semi-permanent waterhole can develop where the rocky embankment narrows the waterway or where a creek descending from the escarpment washes into the rocky outcrop.

The last period of invigorated erosion commenced about 30,000 years ago when the most recent tectonic movement caused local uplift at the basin margin and depressed Lake Eyre itself. This rejuvenated drainage triggered extensive erosion of the gypsite profile dated to the last stable Pleistocene phase of the landform's history. Pleistocene travertine and limestone sediments of gypsite profile stand up to 40 metres high above the recent erosional plane and currently active mound springs. In places this late-Pleistocene dissection removed 30 metres of deposits down to the level of recent river plains (Wopfner and Twidale 1967).

Intensive fluvial erosion slowed at the outset of increased aridity in the mid-Holocene. With such dry conditions, wind became the major force in deflation and redistribution of detritus. This is a situation which largely prevails today (Twidale and Wophner 1990). In the short term however, changes between dry and relatively wetter conditions activate these two forces which influence the dynamic landscape in an intermittent manner. These forces can be easily observed and measured as the destructive factors acting upon the younger archaeological sites (this subject will be addressed later). Sites of Pleistocene origin have had a very slim chance of surviving such massive redressing of the local landscape.

Even a casual traveller may observe evidence of the dynamic forces bulldozing through the landscape. Crumbling crust on the edges of a mesa offers an instructive glimpse into the origin of a gibber. Deep gullies excavated by water often mark the beginning of a creek; with every substantial rainfall, tonnes of soil and rocks tumble down to the creek and the gully extends further up the slope, cutting across the hill. Uprooted trees testify to the changes when a creek cuts its waterway through the banks. The Aboriginal sites located on the creek's embankment are destined to be totally demolished.

Near Ooroowilanie, east of Lake Eyre, flood water burst throughout a sand dune in 1974 (George Bell pers. com. 1990). In this single episode an estimated 20,000 cubic metres of soil and portion of an Aboriginal site were spread over the vast gibber plain. This local catastrophe left no sign on the gibber; thousands of tons of soil have vanished, and an estimated 2,000 stone artefacts discarded over the area is negligible. With a density of one artefact per 125 square metres, such a scatter is invisible on the gibber. On the other side of the dune, however, a dramatic gullying process has been activated as water is violently making its way towards the new gap.

In dry conditions a spectacular dust storm can display the capacity of wind in destruction and transportation. On a daily basis, aeolian forces keep building and re-building local landforms. Near Old Finniss Springs (Hermit Hill North) wind has moved a dune away from the creek. Left behind are the pillar-like remnants of the dune, standing up to two metres high. By interpreting distribution of plants and stone artefacts on a dune, it is possible to infer that this move is a recent phenomenon, probably activated less than two hundred years ago. Observations I made at Welcome Creek suggest that in places, half a metre thick patches of sand can be deposited over night, and shifted elsewhere the next day. This is a very dynamic environment.

A gibber plain is especially harsh and inhospitable. Explorer J.M. Stuart wrote in his journal in 1859 'To-day has been hot, and the reflection from the white quartz and the heated stones was almost insufferable' (Stuart 1865:97). On 26 December he wrote 'The day was excessively hot [...] the nights are very cool, so that we are obliged to have a good fire on all nights [...] it is so cold in the morning that the men are wearing their top coats' (1865:105). The stony desert seems to amplify all adverse environmental conditions. 'Horses very much done up, in consequence of the ground that we have been travelling over being so rotten and stony. The country is no good' (1865:68). Because of these extremes Aboriginal people tended to avoid gibber plains (Blackman pers. comm 1990; Reuther 1981).

The South Australian mound springs are scattered along the narrow belt running from Lake Fromme to the Witjira National Park (Fig. 2, p.28). Following the edge of the Great Artesian Basin - a huge storage of underground water - the network of springs fed by this water bends around south and south-west fringes of Lake Eyre and extends north to the state boundary (Harris 1981). Between Marree and Oodnadatta, where this network is best aligned in a narrow belt, it is followed by the Oodnadatta Track. About half way between Marree and Oodnadatta, near the settlement called William Creek, the track crosses Warriners Creek. South and east of this creek the mound springs are more manifestly aligned along the basin edge and dense scatters of stone artefacts are associated with them.

To the north of Warriners Creek the mound springs are more widely scattered and less conspicuous (with some exceptions, such as Dalhousie Springs); there are other sources of water here and

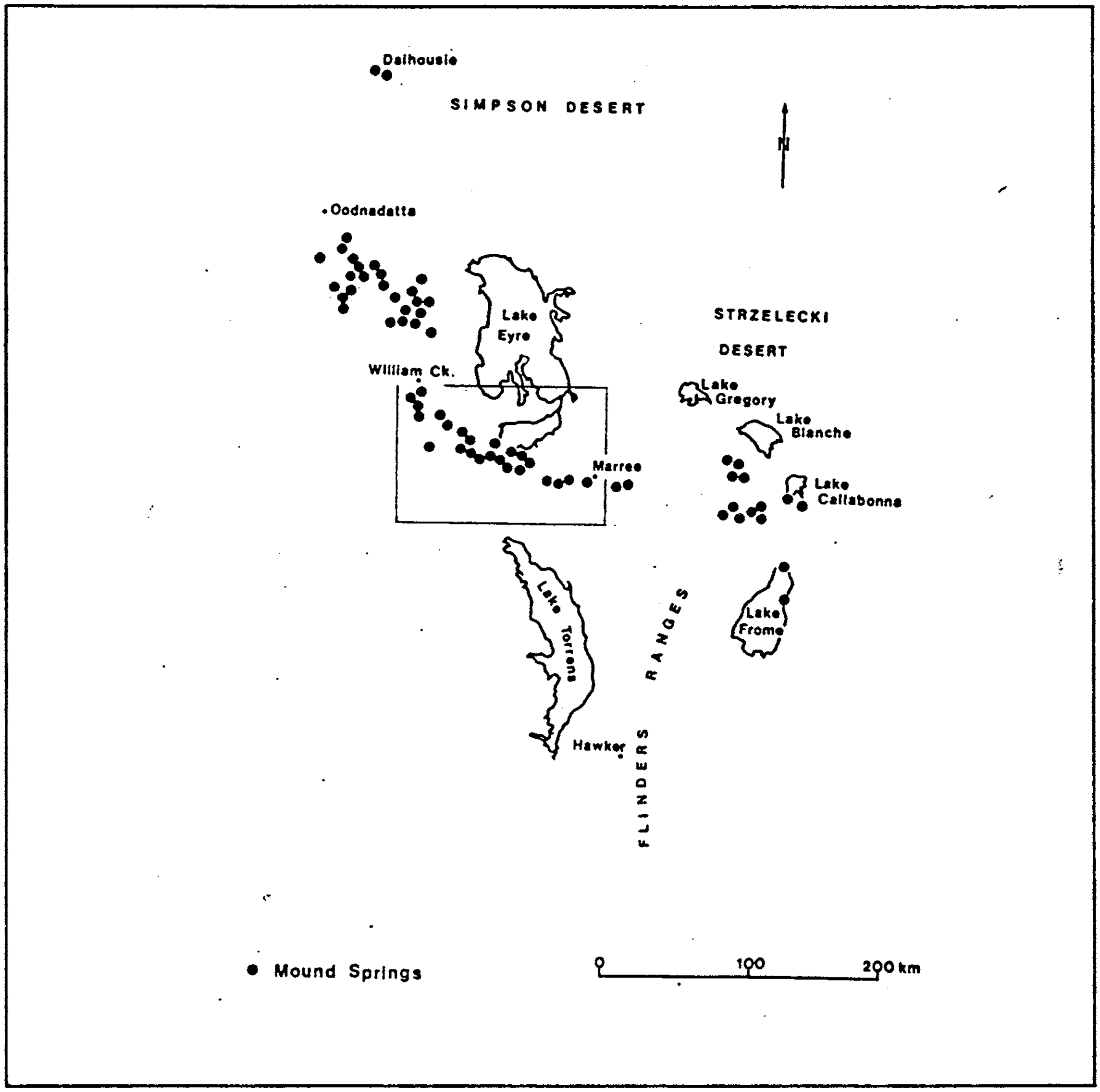

Figure 2. Distribution of the mound springs in South Australia and location of the study area (marked by a rectangle).

the stone artefact scatters are less tightly related to the springs. The other sources of water are spread more evenly over the landscape and some are permanent such as Algebuckina or Eringa waterholes. From the Neales River to the north, the vegetation is richer with more pockets of woodland and tall shrubs along the creeks (Fig. 3, p.29).

During his journey of 1859-60 J.M.Stuart describes the country beyond the Neale as 'good all round' (1865:79). 'No person could wish for better country for feed that we have passed over to-day. [...] The gum trees are large and numerous' (1865:76-77). From the entry on 19 June: 'The Neale - Water in abundance' (1865:83). Stuart reports that his party 'saw two large water holes, one hundred yards wide and a quarter of mile long' (1865:77-78). Then he goes on: 'We come upon two nice water holes with ducks upon them. They are long, wide, and deep. [...] Shortly afterwards we struck (in the gap) two very large water holes a quarter of mile long, and between forty and fifty yards wide, and very deep. [...] We have passed several winter worleys of the natives, built with mud in the shape of a large beehive, with a small hole as the entrance. Numerous tracks all about the creek ' (1865:81-82).

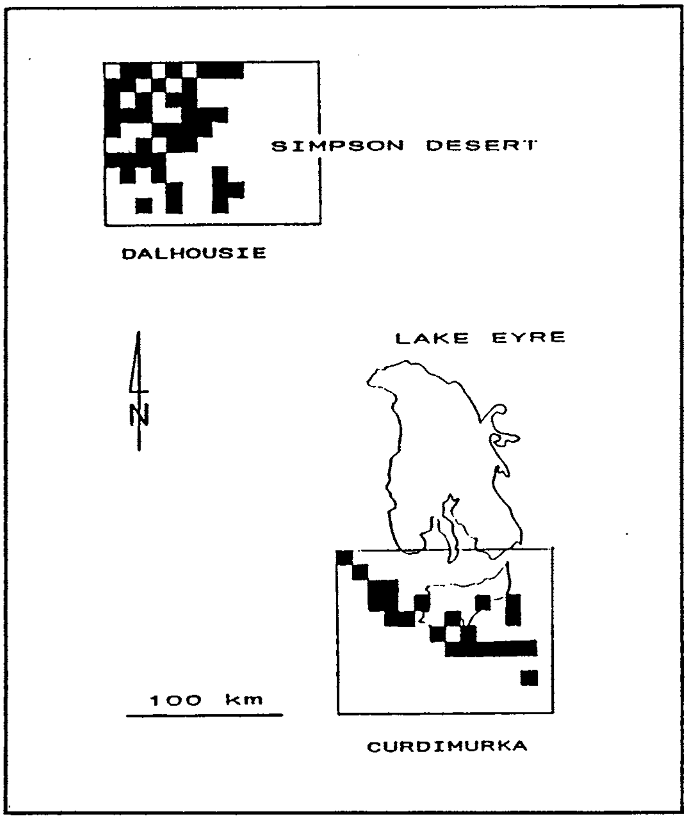

Figure 3. Distribution of permanent sources of water in two areas: Curdimurka (study area) and Dalhousie. 10 km squares are marked black where at least one permanent source of water is present.

On his way back Stuart makes an explicit comparison. 'I can see the line of the Neale running eastward; it spreads out over the plain. It was my intention to follow it until it reached the lake, but I found the ground too stony for me to do so. [...] At this point the trees cease. I can see nothing of the lake. Camped on a gum creek without water. The latter part of our course was over a very barren and rotten plain, surrounded by cliffs of gypsum, quite destitute of vegetation' (1865:83-84). 'We are now approaching the "spring" country again' (1865:82).

For practical purposes the area referred to here as the mound springs country is more narrow, encompassing the south-est part of the springs network, within a tribal teritory of Arabana and Dieri people (Tindale 1974; Shaw and Gibson 1988). It is the area stretching for two hundred kilometres between Marree and William Creek with forty mound springs aligned in a narrow belt. The mean distance between the springs is 10.4 kilometres; the single longest distance between two neighbouring springs is 22 kilometres (Fig. 4).

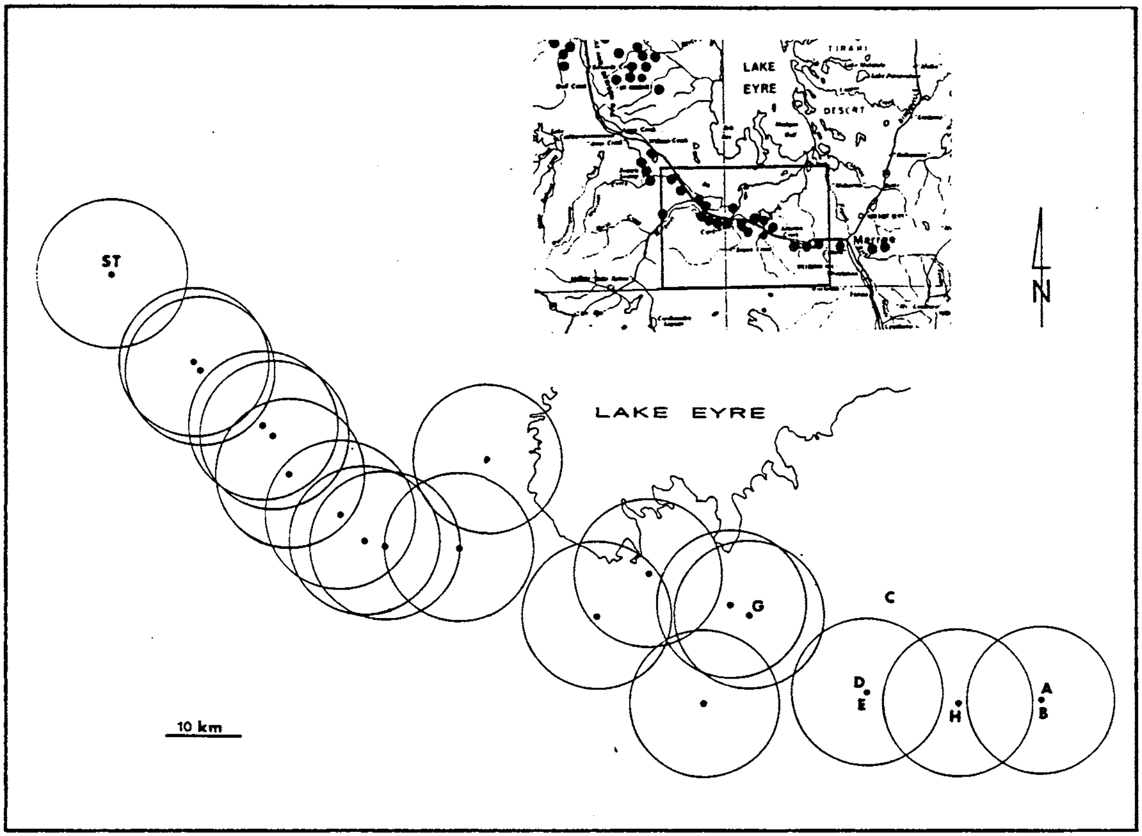

Figure 4. Major springs between Marree and William Creek. The circles of 10 km radius show the short distance between the springs. Letters A-E, G, H and ST designate archaeological sites included in this study.

Most of the springs are situated on the low flood-plains and in the creeks (Photo 3). Reflecting the low relief of the area, only one quarter of the springs is elevated higher, between 30 and 50 metres above sea level. Half of the springs are located between 0 and 20 metres above sea level, while one quarter is at or below it.

The mound springs located on the low flood-plains, (below 20m above sea level), are often associated with low shrubs and perennial vegetation with a significant absence of wood for fire and crafts. Scatters of artefacts related to such springs are far less dense (eg. Emerland springs, elevation: 0 m).

The water from the springs varies in quality. Whenever the outflow is plentiful the water is of excellent quality (eg. The Bubbler, Old Finniss Springs); those springs that discharge a small volume of water are brackish and contain more salt in solution. It has been estimated that the impact of artesian bores sunk in the Great Artesian Basin during the last hundred and fifty years reduced outflow of many springs to one third of their original volume (Holmes et al. 1981).[1] Early explorers were impressed by the mound springs: 'There is an immense quantity of water flowing from them', wrote Stuart (1865:52). It is likely that in the pre-colonial times Aborigines maintained the artesian springs by clearing the outflow of water and removing muck (L.Blackman pers. comm. 1990). 'Discovered a spring in one of the creeks [...]; the natives had cleared it out, and the water [...] was very good' (Stuart 1865:127). Even now, most of the springs provide potable water. The estimate shows that total output of the South Australian mound springs is 1,500 L/sec (Habermehl 1980, 1986) but 80-90% of this volume is supplied by Dalhousie Springs alone, located far north, outside of the area of this study.

Plants which rely directly on the spring water are reeds and rushes, although the black oak (Casuarina) is probably related to the springs also. Other vegetation in the spring vicinity is coincidental, often related to the creek or dune. Typically there is no significant body of water at the spring; only a small pool of water that is usually shallow and salty. However even such water attracts a variety of birds and insects and in some pools small fish, molluscs and amphipods are present. Observations I made near the larger ponds (eg. Hermit Hill North) provided ample evidence for the night watering of large animals such as dingos and kangaroos. In November 1859 Stuart wrote in reference to William Springs 'Immense number of tracks of emu and wild dog, also some native tracks, all fresh' (1865:93). Aboriginal people were perfectly aware of the water quality of the different

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[1]. However there is no strong evidence or consensus about overall lowered output from the springs in the area, see Boyd 1990.

springs, but above all they made a precise distinction between spring water (brackish water) and clear water from soakage or rockhole (Hercus and Sutton 1985:14).

4. Climate

According to the mean annual rainfall the area of Lake Eyre is situated in the most arid part of the Australian landmass. An annual mean of 125mm is quoted by various sources (Laut et al. 1977; Murrell 1984). This is about half of the mean for Broken Hill, Eucla, and Alice Springs. While Eucla receives most of its rainfall during winter months and Alice Springs during summer months, Lake Eyre is more similar to Broken Hill where the rainfall is aseasonal.

Rainfall is highly erratic and it varies greatly between the years. While there are some years that the annual mean is exceeded several times there are also years where rainfall does not occur at all. Generally, droughts seem to be more predictable than rainfalls. The variability of annual figures in arid Australia is 10% greater than the world average for areas with the same annual rainfall. Thus, plants, animal and people must cope with unpredictable fluctuations in moisture between days, months and years (Morton 1990).

Typically for desert rain, it does not fall evenly over the whole area, but is distributed as scattered showers (Photo 2). During a single storm only a portion of the area may receive rainfall. A single fall of rain may cover areas as small as 5-30 km^2 (Fleming 1978). The following remarks are common in travellers journals: 'Heavy thunderstorm from the south-west, but very little rain. [...] Heavy clouds, but no rain' (Stuart 1865:117). 'The storm continued during the night [...] a few drops of rain fell, but not enough to be of any service to me. [...] I think some rain has fallen in that direction' (1865:118). 'Apparently much rain falling there, but none come down our way' (1865:132).

Evaporation is high with an annual mean of 3600mm throughout the year. Surface water dries up quickly and only substantial rainfall feeds in waterholes in the area. Although local heavy rain may occur, filling up creeks, it usually flushes through rapidly and the water that remains in billabongs becomes salty in a couple of days if not hours. Large pools of water such as Lake Eyre itself and several 'lagoons' do not provide any fresh water at all. Some large trees along the creek are able to reach the moisture many metres below the surface but this source is not available to most animals nor to people.

The climate is warm to hot in summer and cool to cold in winter with up to a hundred frosty nights per year. On 12 July 1858 Stuart (1865:21) remarked ' There was very heavy white frost during the night and it was bitterly cold.' Temperatures on summer days are frequently about 40°C and extreme air temperatures are occasionally recorded around 50°C. Average daily hours of bright sunshine vary from seven in winter to twelve in summer (Linacre and Hobbs 1977). On a sunny summer day the temperature of the ground surface can exceed 70°C. As the dark-red colour of the gibber absorbs more solar radiation the stony desert is especially harsh in the summer heat. Because of the scarcity of natural shelters any larger grove of shrubs seems to be a valuable resource in winter and summer alike. Shade is vital for comfortable rest in the excessive heat of a summer day. In winter sufficient material for the windbreak and ample supply of firewood is equally important.

While the occasional floods can cause temporary discomfort or even local destruction there are long droughts which make life in arid Australia especially harsh and difficult. Plants and animals in this region developed several different strategies to cope with this most demanding aspect of the natural condition. But droughts usually take a heavy toll on desert wildlife and while television brings us distressing glimpses of dying cattle, sheep and feral horses the truth is that native fauna always suffered severe mortality, and so did people.

5. Flora

All plants in arid Australia face the same problem, scarcity of nutrients. The levels of two most important nutrients, nitrogen and phosphorus, are much lower than in more humid areas, but they are also significantly lower than in other arid regions of the world. 'The nitrogen content is about one-half and the phosphorus content about one-third of the amount in other deserts, and the trends with other nutrients are similar' (Morton 1990:126).

The bladder saltbush (Atriplex vesicaria) growing in isolation from other plants provides a good illustration. The widely spread root system allows the plant to draw nutrients from the large volume of soil. At the same time the area around the bush becomes depleted of nutrients, preventing other plants from growing nearby (Hurditch 1990:53).

Ephemeral plants demonstrate the same problem. Their seeds germinate quickly after heavy rains but nutrients are in such short supply that they are all incorporated into the body of plants. Therefore, further heavy rain can not stimulate any extra growth until the former generation of plants have died and decayed (Morton 1990:131).

The unreliable supply of water is another, often more visible problem of life in the desert environment. In arid Australia plants developed several strategies for survival. There are two general types. One, the more common, is drought-evading strategy, with many ephemeral species whose dormant seeds germinate only after rain; the plants then reproduce and die. The other type is drought-tolerant.

Mulga is the best example of a drought-tolerant species. Once established from seedlings, mulga plants can survive all but the most intense droughts. Many live for more than 100 years, and the age limit is about 250 years. The reproductive strategy of mulga requires ample summer rains to produce large numbers of flowers, and heavy winter rains to set seed. This dependence on a sequence of heavy rains in summer, winter and the following summer sets a limit to the mulga's success in establishing the new seedlings. Because of this, the widespread regeneration of mulga takes place only about once in a decade. (Morton 1990:126-8).

To cope with unpredictable rainfall, bladder saltbush (Atriplex vesicaria) can flower at any time of the year if rain supplies enough water. Its seed remains viable for several years. The plant grows rapidly in favourable condition but stops growing and prevents water loss by shedding its leaves during a dry period (Morton 1990:128).

Ephemeral plants do not have the resistance to dry conditions and they must grow, flower and set seed rapidly. When rain comes in the Lake Eyre region, ephemeral plants spectacularly transform the desert into a carpet of green with millions of unfolding flowers. Many species take only three months to grow and set seeds so, the lavish spectacle is short and the blossoms last only a couple of weeks.

The plants of the area are also affected by long-term fluctuations in rainfall. After long drought regeneration may not come immediately and its success depends on the pattern and intensity of rain. So, the rainfall appears to be the truly vital force in the region. Both nutrients and water tend to concentrate along the creek lines and dunes while the surrounding plain may be greatly deprived of these important resources. This is reflected by the overall pattern of plant distribution in the area.

The vegetation of the mound springs country is characterised by two plant communities. Most of the area is the low shrubland of Atriplex rhagodioldes with the pockets of tall shrubland of Acacia ramulosa and Acacia aneura. At the north-west fringes just beyond the spring network, there is a hummock grassland with Zygochloa paradoxa and Triodia basedowii, and the pockets of Acacia aneura and Atriplex vesicaria (Lange 1983).

In general the low shrubland of saltbushes (Atriplex) is associated with a gibber; the hummock grassland of cane grass and spinifex is related to the sand ridges. Tall shrubland with the most characteristic mulga (Acacia aneura) is dispersed in small groves along the creek lines and on the flats between the sand dunes.

While most of the area is gently undulating gibber plain with low, sparsely scattered shrubs, there is more variety in vegetation near the waterholes, billabongs, ephemeral swamps and along the creeks. Examples of local vegetation are given below with the emphasis put on the plants that played an important part in foraging economy (Cleland 1966, Hetzel and Frith 1978; Latz 1982).

At some freshwater pans and swamps the nardoo fern (Marsilea drummondii) can be found. Its little seeds were collected and ground into a flour by Aboriginal women in many parts of arid Australia.

Several species of grass known for their value for grazing animals are spread in small patches on flood plains. Among them are the Mitchell grasses (Astrebla lappacea, A. pectinata), the mulga grasses (Aristida contorta, A. anthoxanthoides, A. capilliofolia), button grass (Dactyloctenium radulans) and wanderrie grasses (Eriachne aristidea, E. benthamii). Kangaroos are especially keen to graze on the young shoots of these grasses.

The native millet (Panicum decompositum) is a grass whose seeds were ground, cooked and eaten by the Aborigines.

Spinifex and porcupine grass, which are rare apart from the north-west fringes of this area, were the source of the best quality adhesive used in many crafts.

A succulent plant known as a pigweed (Portulaca oleracea) was valued for its moist and soft leaves eaten by children and elderly people; when dry, the seeds were ground for flour.

On the sandy soil several species of lily can be encountered. Among them are the sand lily (Caesia lateriflora), fringe lilly (Thysanotus exiliflorus), leek lily (Bulbine semibarbata), and early nancy (Anguillaria dioica). These were sought by the Aborigines for the moist fleshy tubers.

There are a few species of subshrubs such as saltbushes (Atriplex vesicaria, A. nummularia) and bluebushes (Maireana aphylla, M. astroticha) that are the most prominent on the gibber and flood plains. While the large stretches of shrubland may feature one or two shrub families as the bulk of vegetation, a wide range of other shrubs mixes in where the habitat varies slightly.

Tall shrub flora is represented by several species of acacia. The umbrella bush (*A. ligulata*) was a source of edible seeds and the wichetty bush (*A. kempeana*) was sought for the grubs in its roots.

The most common tree is mulga (*Acacia aneura*) whose seeds are one of the most important food staple, Stuart comments: 'we had camped close to a large quantity of acacia seed that they [Aborigines] had been preparing when we arrived' (1865:114). Mulga provided hardwood for a variety of crafts especially important for digging sticks, spear-heads and barbs, and also excellent firewood.

Similar but far less common is gidgee (*A. cambagei*), often with a more prominent trunk and still tougher wood. Gidgee wood is valued as the best quality fuel; slowly burning coals can generate heat through the night. It is also used for wood-craft.

Other acacia species are represented by ironwood (*A. estrophiolata*), Broughton willow (*A. salicina*), dead-finish (*A. tetragonophylla*, *A. stenophylla*) and others. They were all the source of seeds and wood for various crafts and the firewood.

Similar use was made of several other trees such as beefwood (*Grevillea striata*), needlewood (*Hakea leucoptera*), corkbarks (*H. ivoryi*), whitewood (*Atalya hemiglauca*), blackoak (*Casuarina cristata*), sandalwood (*Santalum lanceolatum*), and desert willow (*Pittosporum phylliraeoides*).

The eucalyptus family is represented by several species found only near the major waterholes or along the large creeks. They are coolibah (*E. microtheca*), northern river gum (*E. camaldulensis*), river box (*E. largiflorens*), and bloodwood (*E. dihromophloia*, *E. terminalis*). The large trees provide nesting sites for birds, a variety of insects including honey-bee, lizards, and 'camping sites' for kangaroos. They also provide bark and timber, firewood and resin for people. 'The gum-trees were large; from one of them the natives had cut a large sheet of bark' (Stuart 1865:77).

6. Fauna

The variety of creatures populating the Lake Eyre region is impressive. However, commonly this area seems to be desolate. A casual traveller is likely to notice only bush-flies, ants, some lizards and several birds. The local fauna consists of creatures which are able either to withstand drought and food shortages or to escape.

There are approximately 200 bird species most of which are nomadic. They can undertake long distance migration or shorter shifts from one area to another. Most mammal species are tiny burrowing omnivores able to avoid heat and to utilise a variety of food resources. The desert crab can survive for more than one year without food while slowing down its metabolism (Greenway 1984:151). The four-stage life cycle of insects allow many of them to stay dormant until favourable conditions unleash suspended activity. Desert wasps are flexible in their diet, they can eat almost everything from another wasp, fly or spider to flower nectar. A native cockroach eats the leaf litter, a hard fibrous material useless to any other herbivores. Desert frogs store water in their bodies while dormant about a metre below the ground. Many ants customarily store food. Some reptiles do not need to eat regularly and can go for months and years without water.

While life is never completely suspended, even in the middle of drought, it often hides and lays quiescent. Many potential resources are of no value unless transformed into the body of a fish or kangaroo, into the fruits and seeds of plants. The times of plenty are short and spasmodic, whimsical like rainfall itself. Day to day existence is harsh, with scarce resources, excessive heat, cold and drought. The list of animals may imply a false picture of opulence, but reality is lean and so are the inhabitants.

'Unlike some birds and most large mammals, most desert-dwelling animals can survive quite easily without drinking water. The biggest problem they face is how to obtain sufficient food.

In the arid zone, the pursuit of food by animals is comparable to the search for nutrients by plants and it is usually the critical factor in their existence. The survival of animals of the arid zone is thus greatly affected by the variability of food supply' (Morton 1990:134).

In contrast to common assumptions the stony desert is a home for many insects although the total number of them is not yet scientifically documented. Insects are either a substantial or supplementary portion of the diet of reptiles, birds and mammals. Only a few insects were used in a direct way as sources of food or craft material by the Aboriginal people. Some examples are provided here to illustrate the variety of resources available to the mound spring inhabitants.

In arid Australia about 250 species of granivorous ants are present. Harvester ants store seeds in their nests. Such a readily available food source was much appreciated by the Aborigines because collecting seeds is a time consuming and tedious job.

Witchetty grubs, a nutritious and tasty food, are found on the acacia roots and are highly valued in all arid Australia. In good conditions the plague locust (Chortoicetes terminifere) can erupt in astonishing numbers. It is easy prey to collect even by children, and is often roasted in hot ashes before eating.

While the insects provide an important portion of a diet for terrestrial fauna such as reptiles and mammals, there are shrimps and fish which attract millions of pelicans and cormorants, stilts and silver-gulls to Lake Eyre during floods (Bonython and Fraser 1989; Serventy 1985; Kotwicki 1986). There are thirteen species of freshwater fish recorded in Lake Eyre, the most common being the bony bream whose body is packed with bones. When bream are dying in their millions on the lake shore, they are scavenged by reptiles, birds and insects. Also common are the hardyhead and toughest of them all, desert goby. There are also freshwater clams; fairy and shield shrimps.

While an initial flooding of the lake brings a large body of fresh water, the bottom level becomes increasingly salty, and as the water is mixed by natural currents and waves, the salinity becomes common in the whole lake. Some freshwater fish of this region can tolerate a high salt content, but there is a limit to this and in the latter stage the lake is overtaken by saltwater creatures. Salt-lake snail and brine shrimp are the obvious examples. Australian brine-shrimp (Parartemia) which hatch quickly in the flooded lakes provide an ample supply of food for variety of birds. Banded Stilt (Cladorhynchus leucocephalus) rely for its breeding on this lavish, although erratic resource (Phillipps 1990).

Although most of the fish die, falling victim to birds, salt, rapid changes of temperature, lack of oxygen, or stranded by algae and reseeding water; many manage to lay eggs which will wait, sometimes many years, for another flood. Fish such as the spangled perch or gruntar can aestivate in the damp mud of lagoons and pools that have dried out.

However, most of the fish are flushed in with every new flood from the permanent billabongs and pools far away up the rivers. The same flood washes in microscopic floral and faunal material which flourish in the lake, providing food for larger shrimp and fish. Fish recorded in the springs are small but there are fish in larger water holes and billabongs. 'On the banks a number of natives have been encamped; round about their fires were large quantities of the shell of the fresh-water mussel, the fish from which they had been eating' (Stuart 1865:113).

N.B.Thompson (1985) records 24 species of reptiles observed near selected springs and bores. Most of them are lizards and geckos. However it seems that distribution of reptiles is not related to spring water but rather to limestone outcrops. Some lizards and snakes can go for years without drinking, taking sufficient supply of liquid with their food. Because many reptiles do not use much water for thermal regulation and can tolerate very high salt content, they are efficient in conserving water. Many reptiles are often found in rocky outcrops and on the gibber, and approximately 30 common species can be found in the mound spring country.

Lizards are regarded as the most common and reliable source of protein for desert dwelling Aborigines. Ground goanna (Varanus giganteus), the largest monitor lizard (often 2m long) is much appreciated food package. Aboriginal people developed a special strategy for digging it up from underground burrows.

Smaller lizards are collected frequently as they are encountered on the foraging trips. Shingleback lizards and the bearded dragon, both about 30cm long, are especially common in the Lake Eyre region and half a dozen of such lizards would provide a good meal for an Aboriginal family.

In the rocky areas and on the sand dunes the Western Brown snake is common. The smaller, highly venomous desert death adder is seen less often. Although both are large enough to be contemplated for a meal, it appears that snakes were not high on the menu.

One amphibian, a water-holding frog, should be mentioned as it provides both food and water. While active in the pools of flood water, in the up-coming drought this frog can burrow in the ground and survive for several years on its storage of fat. The water-holding frog is cherished as a tasty snack and drink, worth digging from up to a metre below the ground. For the desert dwellers an opportunity to drink is as important as an opportunity to eat.

F.J.Badman (1983) provides the list of birds recorded in the Marree area on the south-eastern fringes of Lake Eyre. The list contains about 200 species. 45 species are identified as residents but 110 breed in the area. There are many nomadic birds such as galahs and stilts; others are migratory such as blue-winged parrot and plovers.

Birds and their eggs are a source of protein but many birds exploit resources which are also sought by people. For example the Galah (Cacatua roseicapilla) and Little Corella (C. pastinator) feed on the great variety of edible seeds. Both birds exploit gibber and saltbush plains and are common visitors at the creek beds, waterholes and springs. An individual bird can pick up several thousand seeds a day. In the old days these parrots were hunted for the seeds collected in their gizzards. When softened in the digestive fluids, the seeds were highly valued as food, known in the outback as porridge (Lucky Blackman, pers. comm. 1990). In the second half of this century the number of parrots drastically declined due to depletion of plants caused by the pastoral practices of overstocking.

Several species of honeyeaters are known as the "blossom nomads" in the areas of irregular rainfall. They feed on the nectar, fruit, and sugary secretions of herbivorous insects. Honeydew, lerp and nectar of flowers are rich in carbohydrates (Simpson and Day 1988). Such sugars are a valuable addition to food procured by the Aborigines. Flocks of honeyeaters can lead people to the various sources of sugar and sought after fruits such as the mistletoes - a parasitic plant growing on the Acacia and Eucalyptus species (Goddard and Kalotas 1988).

Emus are one of the birds which breed in the region, although many emus migrate south to the Flinders Ranges where more reliable and abundant winter rainfall promises better fodder. For the emu a 500 kilometres journey is a viable endeavour. In early autumn and throughout the winter families consisting of one male and from one to three females lay 9 to 12 eggs (sometimes as many as 20). Their preferred nesting habitat is a flat between small sand ridges (Simpson and Day 1988) and if the eggs are taken away or destroyed early on, the family is likely to lay another set of eggs in the same 'nest' to proceed with the breeding duty. A clutch of freshly laid eggs is considered a very rich food supply for several Aboriginal families. The value of this food can be illustrated by the fact that even eggs in an advanced stage of incubation are eaten. Typical preparation of eggs is by cooking on a low fire for several hours. An adult emu is a large package of meat worth hunting for, and the skin, feathers and sinews were used as the raw materials in various crafts.

Twelve species of large to largish birds are grouped here together because they inhabit similar areas, from dry grassland to marshes. Some of them are common, for example Australian Crake (Porzana fluminea) is a resident of well vegetated swamps; monogamous Brolga (Grus rubicundus) can travel long distances in search for food but often breeds in the same traditional location near springs. Quails, Wanderers, Rails, Crakes, Coots and Native-hen are to a varying degree nomadic and opportunistic. Some can suspend breeding in unfavourable conditions. The Australian Bustard is a large bird which stands up to 1m. Habitually it hides in tall grass but its strong curiosity makes it relatively easy prey, and it is highly valued game.

There are many birds which live or often visit gibber plains. Some are small such as Zebra Finch (Taeniopygia guttata), Crimson and Orange Chats (Ephtianura tricolor, E. aurifrons), some larger like Crested Pigeon (Geophaps lophotes). Rocky cliffs and outcrops are the favourite habitats of carnivorous birds such as large Wedge-tailed Eagles (Aquila audax), several Kites, Falcons, and Hawks. Other birds prefer more shrubby areas closer to the water' for example the Black-eared Cuckoo and Australian Magpie, Swallow and Martins. The Australian Raven (Corvus coronoides) and Little Crow (Corvus bennetti) can be found in many habitats as they are opportunistic omnivores.

Several species of medium size birds exploit shallow saltwater of lakes and lagoons. They are Plovers, Stilt, Stint, Greenshank, Red-neck Avocet, Caspian Tern and Silver Gull.

Twenty seven species of large nomadic waterbirds were recorded in the area (Badman 1985), from Black Swan, pelican and cormorant to variety of ducks. One third of them are classified as frequent, and nine breed in the Lake Eyre region. Although there is no specific reference to the exploitation of this resource, it is likely that these birds were hunted and their eggs collected by the mound spring inhabitants.

After heavy rains when the lake is flooded providing an abundance of fish and shrimp, there is an influx of migratory birds especially pelicans, gulls and cormorants. In the short outbursts of plenty they procreate with 'wasteful' intensity. Shrinking water, increasing salinity and approaching drought eventually kills late chicks in their millions before the survivors are able to join adults in the retreat journey south.

Dieri people of the Lake Eyre region had names for sixteen mammals, all hunted for food. It is likely that before European colonisation about 40 species of mammals were present in the area; many of them now extinct. Some of them were as common as the Dusky Hopping-mouse (Notomys amplus) and several species of bats, especially Vespertilionidae Family; some as rare as Echidna (Tachyglossus aculaetus) and Common Brushtail Possum (Trichosurus vulpecula). Most of these animals are small; from the Sandy inland mouse (Pseudomys hermannsburgensis) of 12 grammes to the Western Barred Bandicoot (Perameles bougainville) of 220 grammes. There are a few larger animals such as Brush-tailed Bettong (Bettongia penicillata) of 1.3 kg and Bilby (Macrotis lagotis) of 2.5 kg. Larger still is the placental Dingo (Canis familiaris) and the most prominent marsupial, Red Kangaroo (Macropus rufus) whose males weigh up to 85 kg. Other kangaroos found occasionally in this region are Western Grey Kangaroo (Macropus fuliginosis) and euro (M. robustus) (Strahan 1983).

Although many of these mammals may have been hunted, it seems that the Red Kangaroo, as a large animal, was worthy of special attention. The Red Kangaroo procreates when the good season promises success in rearing offspring. When time are harsh the population size decreases and a small number of animals survive on the dwindling resources until more favourable condition permits them to procreate again.

Drought is characterised by food and water shortage and dwindling population of Red Kangaroos encapsulate this fluctuation in time. However suspended breeding and population decrease is only a part of a species' response to the severe environmental stress. Behavioural surviving strategy is a far more positive response to overcoming stress and coping with harsh conditions on a daily basis.

7. An example of behavioural adaptation of animals

There are several studies on the behavioural response of different species to the harsh desert conditions. It seems that some aspects of the behavioural adaptation of Red Kangaroos are especially relevant to the understanding of a dynamic relation between arid environment and population of large animals. Although the observations related here are from Denny's (1982) research carried out in north-western New South Wales they are transferable to other parts of arid Australia.

In the areas with sufficient variability of landforms, vegetation and water sources, the Red Kangaroo is not nomadic but travels within a large but circumscribed home range. This is an area with a radius of 10km or about 300km2. With several watering points in this home range Red Kangaroos can move about utilising different habitats. Quantified data suggest that about 80% of the local population tends to stay within the home range and they are usually adults of both sexes. The remaining 20% that ranges farther afield, (100 to 300km away), appears to be predominantly young males. Dominance hierarchies within a Red Kangaroo population have been suggested as the explanation. Young males, unable to mate with females because of elders' dominance, are forced to leave their original home range in search for other breeding sites (Denny 1982:182).

It was found that kangaroo densities vary significantly between different land systems, for example sandhills and alluvial plains support more kangaroos than other formations. There is no difference for males and females in this respect. There is also significant seasonal variation. For instance a creek-line shows a higher density of Red Kangaroos in summer than in winter, whilst more kangaroos are on a rolling stony downs in winter than in summer. The creeks with a denser cover of tall shrubs and trees than the rolling downs provides shelter from solar radiation (Denny 1982:181; also Croft 1991).

A dried-up swamp covered with tall shrubs attracts high number of kangaroos in winter, despite the fact that food available in such swamps is scarce. The animals are after shelter from the cold wind while they bask in the sun. Similar areas such as grassland lightly covered with tall shrubs, also support higher number of animals in winter.

Other habitat preferences of Red Kangaroos are related to the food supply. Many studies have emphasised the positive relation between red kangaroo density and short, sparse green fodder known as 'pick.' Where the grass contains high percentages of water and nitrogen a high number of kangaroos can be expected. Where the grass is dense and tall, few kangaroos may be found. Small areas of green feed may occur as a consequence of fire or localised rainstorm. In such areas with rapid regeneration of grass and 'forbs' the density of kangaroos can be 270 times the density in dry areas. In the flat country a local rainstorm can be seen from 20km away. Red kangaroos can sense a rainstorm and they often travel up to 30km to take advantage of these small fertile episodes (Denny 1982:182). It is known also that regeneration of bush burnt by Aborigines as a management strategy attracts kangaroos (Cane and Stanley 1985).

Distribution of land systems, resources and climatic fluctuation through time stimulate kangaroos to move around, to utilise, in the most economical way, what the land has to offer. In a desert the optimal climatic condition and the food supply required by the animal are rarely met. To satisfy these needs the animal must move from one area to another, seeking shelter from cold in winter and refuge from heat in summer. Food requirements and supply too vary through time and space. In the summer heat easy access to water is crucial; in winter this dependency on water can be relaxed. The patchy rainfall stimulates regeneration of plants in an uneven manner and for grazing animals such as the Red Kangaroo to follow these patches of fresh growth is the most obvious response.

8. Towards a model of human occupation

Better understanding of peoples' behavioural response to the environmental constraints can be furnished by looking at human population as part of an ecosystem (eg. Birdsell 1953, Jones

1977; Foley 1984; Pardoe 1991; Clark and Lindly 1991). The environmenal characteristics of the area and its geography provide some basis for predicting the nature of human occupation.

To begin with anecdotal evidence, a strategy of land use similar to that of the Red Kangaroo was adopted, in a very crude form, by pastoralists. 'Cattle and sheep, fattening during good times, had to be shifted in droughts. Sydney Kidman learned his lesson when his station properties suffered in the drought of 1901. He battled on until his empire covered nearly 300 000 square kilometres. Because of the size and spread of his holdings he was able to shift stock, following the rain, in the pattern of desert birds such as budgerigars and gray teal' (Serventy 1985:17).

Numerous anthropological studies show that organised movement within a circumscribed range is the common characteristic of hunter-gatherers around the world. In contrast to the animals, people plan their movements ahead, based upon a substantial component of traditional knowledge of land and its nature. The point is that spatial variability of land systems and temporal fluctuations of climatic conditions and resources, make such movement important, if not crucial, in the foraging and general living strategies (Davies 1984; although there are other factors of mobility, eg. Young and Doohan 1989). The best anthropological examples are those of the seasonal movements, well patterned and fitting with the year cycle (eg. Thomson 1939). Seasonal movements are also well reflected by archaeological material in many areas of the world and in Australia (eg. Schrire 1982; Cane 1984).

However, like droughts and rainfall, occupation of the mound spring sites seem to be aseasonal. Therefore the archaeological deposits have been largely accumulated in dry periods rather than in specific seasons. Climatic conditions were harsh and the food resources scarce for most of the time, forcing people to rely on the springs for water but also to move from spring to spring in search for food. An environmental model suggests that the longer and more severe the drought was, the stronger the pressure to stay at the springs but also to move more often along the springs network. Wetter, but short periods, relaxed this dependency on permanent water, creating sound incentives to forage away from the springs. A large number of transient habitation sites located far from the spring network support this assumption. This can be also inferred from scanty ethnographic records and oral tradition (Reuther 1981; Hercus and Sutton 1985; Shaw and Gibson 1988;).

This environmental pressure on people was strong and real. It has been recorded that desert dwelling Aborigines sustained some losses accounting for 10% to 25% of the population depending on the length and severity of drought. In such time up to 50% of children under 5 years of age were likely to die and child-birth in times of drought was often responded to by infanticide (Strehlow 1965:131; Kimber 1990:164-5). Many losses resulted from miscalculations concerning the length of drought and reliability of a waterhole. Sometimes, trapped at an isolated waterhole with all food resources depleted people faced starvation (Cane 1984). In contrast the mound springs inhabitants were in a better position; as soon as people moved their camp to the spring, any spring, they gained easy access to the whole spring network. This network also provides a passage down south to the Flinders Ranges and up north to the Macdonnell Ranges. The mound spring country was a section of the long trading route, along which some goods and foreigners passed both ways (Cleland and Tindale 1936; Jones 1984; McBryde 1987; Shaw and Gibson 1988).

What in other parts of the country can be referred to as subsistence mode, here rightly can be called survival strategy. This means that people were under strong pressure to develop an efficient (or workable) strategy to comply with the stern rules of the desert. Once such a strategy was developed it was wise to adhere to it, even with calculated loses. Such environmental constraints suggest that patterns imprinted in the archaeological remains and their distribution over the landscape would reflect some aspects of this survival strategy. The archaeological signature of this environmental constraints will be elaborated later.

CHAPTER III

ARCHAEOLOGY OF THE MOUND SPRING SITES: BACKGROUND

'We have also found a number of places where the natives have been encamped. They seem to be numerous, judging from the number of places where they have their fires.'

John McDouall Stuart 1865:32

1. Archaeological evidence and culture

In this chapter I present evidence supporting the view that the mound spring sites are habitation sites, that they are distinctively different from the non-spring sites, and that their chronology can be attributed to the youngest phase of the Holocene prehistory. Because the idea of a habitation site is entangled in ethnography and the study of culture (eg. Wobst 1978; Binford 1982), it is necessary to explain how archaeological evidence relates to the human behaviour, often referred to as culture.

A 'culture' is one of the basic concepts of human sciences (eg. Williams 1981; Ingold 1986). Many branches of anthropology are explicitly engaged in studying different aspects of cultural diversity among human population. Archaeology often invokes culture as a frame of reference for diversity encountered across time and space (eg. 'Culture areas are regional groupings of interacting Aboriginal societies possessing broadly similar languages, social organisation and customs, material culture and art styles, lifeways and environment' Flood 1983:192; also Clarke 1968).

The 'culture' however, is too abstract and too global. So, for practical purposes it is useful to dismantle the concept into its components. The culture encompasses a view of the world, values, information system, life-strategy and activities (Rapoport 1990:10). The life-strategy and activities are the most tangible operational concepts that can be discovered and measured in archaeological records. The pattern of various activities in a specific framework of time and space represents the life-strategy. The boundaries of this pattern define chronological and geographical limits of a given population and culture. Within archaeological records, a settlement system best represents this pattern (Chang 1967, 1968; Parsons 1972; Ellison and Harriss 1972; Willey 1974; Clarke 1977; Fish and Kowalewski 1990).

In prehistory the life-strategy can be assumed as an operational concept, parallel to ethnological notion of culture. It provides a framework within which inferences concerning the past human behaviour can be organised in a coherent and meaningful way (compare Binford 1984, 1987a). It also permits verification of such inferences through re-analysis of archaeological records. In this concept, activities are not isolated episodes, but interdependent components of human endeavour integrated within the life-strategy. Interdependence of activities can be defined as complementary and exclusive. Firstly, an activity usually leads to another activity; for example, game killing leads to butchering, flaking stone for sharp cutting implements, collecting firewood, cooking and finally eating. Secondly, an activity usually excludes similar activities in time and space; for instance, a group of people camping on one location can not camp on another location at the same time. In other words, activities are elements of the coherent system (e.g. society). The archaeological record is the product of activities. Different records are linked together in a parallel way to the activities inter-related in the social system. Clues to a link between archaeological records are primarily spatial and temporal association of evidence (eg. Parkington 1980; Kroll and Price 1991), but there are other indications of such association. Examples are re-fits of stone artefacts, similar technology, and identical sources of raw material. Life-strategy can be best approximated by, or inferred from, a settlement system. Territorial analysis 'will give a clue to the function of sites within larger framework of economic relations than is possible by consideration of individual site alone' (Jarman 1972:725).

The pattern of activities is not rigid, tasks can be strung on a time arrow in different sequences in response to changing external conditions. Furthermore, such flexibility is frequently patterned, for example, seasonal modification of life-strategy (e.g. Thomson 1939). Therefore, it is the cyclical repetition of activities, their sequences and the entire strategies that accounts for the preservation of the pattern and consequently, cultural identity of a population.

As a result of its complex interaction with the natural environment, there are certain rules within such a system that cannot be easily broken. It would be difficult to cook first and kill later, or to eat game before hunting. In the field of subsistence and subsistence-related activities (eg. maintenance of implements) there are some rules of economy which prompt people to plan and organise activity in a way that ensures conservation of labour, time and energy or, alternatively, increases the return for investment of work and pain. Ultimately these rules can be reduced into a biological imperative, survival of the fit ones (Eldredge 1989); that is, an ability to produce (or procure) enough without destroying the productive capacity. Such rules guiding social behaviour overlap heavily with what has been termed optimal foraging theory (O'Connel and Hawkes 1981; Binford 1983; Smith 1983; Kelly 1983; Foley 1985; Yellen 1987). In the field of work and work related practices there is a tendency to select optimal solutions within the constraints of a given technology, environment, social structure, and pool of inherited knowledge. This tendency can be illustrated by various ethnographic and archaeological studies (eg. Yellen 1987; Torrence 1989a).

Here are the following consequences for archaeology.

1. The archaeological record is "par excellence" product of past human endeavour, where subsistence and related economic activities are usually best represented.
2. To ensure its existence the social system needs to maintain the balance between returns and production capacity. This is achieved through selecting, planning, and organising subsistence and economic activities within a scheme revolving around optimal strategies.
3. The various activities of a given population are defined within time and geographical space; archaeological records reflect (or mimic) human society by being 'organised' in a spatio-temporal framework. Different archaeological entities are linked together, with the highest practical level being a settlement system which shows geographical (and in a 'silent' way - temporal) boundary of the past population.

The system-like quality of archaeological records is represented by the spatio-temporal organisation of prehistoric settlements. While the settlement system reflects the past society (population), a single habitation site is a rich repository containing evidence of activities that make up the system by fuelling society through subsistence and economic tasks. In the archaeology of hunter-gatherers, the bulk of evidence is directly related or enmeshed into subsistence and subsistence-related activities (Murdock and Morrow 1970). While a prehistoric settlement system may provide a model for a past social system, the multiple occupation site can provide examples of various activities bound to specific location.

2. The concept of the habitation site and archaeology

Archaeological sites can be seen as deposits of the natural strata with an additional component of artefactual material which consists of mineral and organic matter shaped, modified or simply discarded on the locality by people. Reflecting human activities and the use of geographical space, the site is often confined to a small area consisting of relatively high density discard of artefactual material. The density of discard is a crucial factor in defining site boundary. While single artefacts are scattered all over the landscape, larger concentrations of them are conspicuously present only in specific locations (Stein 1987; Nash and Petraglia 1987; Gamble 1991).

It is believed that such distributions of artefacts reflect human activities; implying that people generate less artefactual discard when they are mobile (moving across the country) and more of it when they are stationary (settling on one spot for a period of time). A general assumption is that only stationary human groups produce a high concentration of discard, while mobile groups tend to scatter it over a large area, in which case, artefacts are the vanishingly small portion of natural sediments (Deetz 1968; Foley 1981; Cowgill 1990).

Settling can be conveniently described as habitation and most localities settled for even a short duration of time can be defined as camping sites. Camping usually (although not exclusively) refers to hunter-gatherer societies which are generally mobile and do not construct solid permanently occupied dwellings - characteristic for agricultural and urban societies.

The concept of the campsite is derived from ethnography. It has proved to be extremely useful in archaeology when inferring mobile/sedentary behaviour of human groups and lending reference to speculation about the organisation of the past society (Binford 1980). However, recognising a campsite in archaeological evidence is largely an evocation of the ethnographic concept. This process can often be reduced to the classic analogy where the campsite may be recognised by matching some archaeological attributes with their ethnographic equivalents. Because 'camping activities' often generate relatively complex and durable facilities, such as shelters, fireplaces, storage, and food processing implements, this simple procedure of inferential analogy has been largely successful and commonly accepted in archaeological practice.

Although often pronounced unacceptable, analogy has never been relinquished from our discipline. Analogy provides a basis for the vast range of inferential procedures. The fundamental role of analogy is in establishing a framework with which some material objects can be recognised as humanly-made or modified articles. For example, ethnographic observations and experimental stone flaking have developed into a specialised field of archaeological expertise (eg. Newcomer and Sieveking 1980; Cotterell and Kamminga 1987; Johnson and Morrow 1987; Amick and Mauldin 1989).

Activities associated with camps are well known from ethnographic observations, however, it was only in the last two decades that archaeologists took to the field to see for themselves how archaeological material is generated, discarded, and deposited by recent tribal societies (eg. Hayden 1977, 1978, 1979a; Gould 1977, 1978, 1980; O'Connell 1987; Binford and O'Connell 1984; Cane 1984; Binford 1987b; Meehan and Jones 1988; also Gamble and Boismier 1991 for extensive reference). By that time most of the hunter-gatherers had undergone radical transitions, adapting to live on the fringes of the 'modern' world. The adoption of metal tools and almost total departure from traditional stone craft is one consequence of this transition (Penny and Moriarty 1978:22; Nicholson and Cane 1991:271).

Unfortunately, many archaeological sites consist of little more than large assemblages of stone artefacts. Systematic observation of camping activities never reported such large amounts of stone artefacts being used and discarded. Therefore archaeology, in this case, seems to receive little help from ethnographic studies. The mound spring sites represent this situation. The sites' significant feature is a large, very dense scatter of stone artefacts, without parallel in ethnographic reality (Fig. 5, p.54).

For further discussion it is useful to introduce dichotomy between surface sites that are the subject of this study and buried sites that command most archaeological attention. These sites differ mainly in geomorphic position and degree of exposure. Consequently different methods of data recovery apply to these sites. The buried site requires an excavation technique. The small sampling area and often multiple depositional layers require that the focus is upon the vertical distribution of objects and their relation to natural strata. The succession and chronological resolution of deposits appears to be the major concern at stratified sites. The surface site, on the other hand, shows large areas of exposure and minimal stratigraphy. Here, the horizontal configuration of artefacts seems to be the most important and informative field of archaeological research.

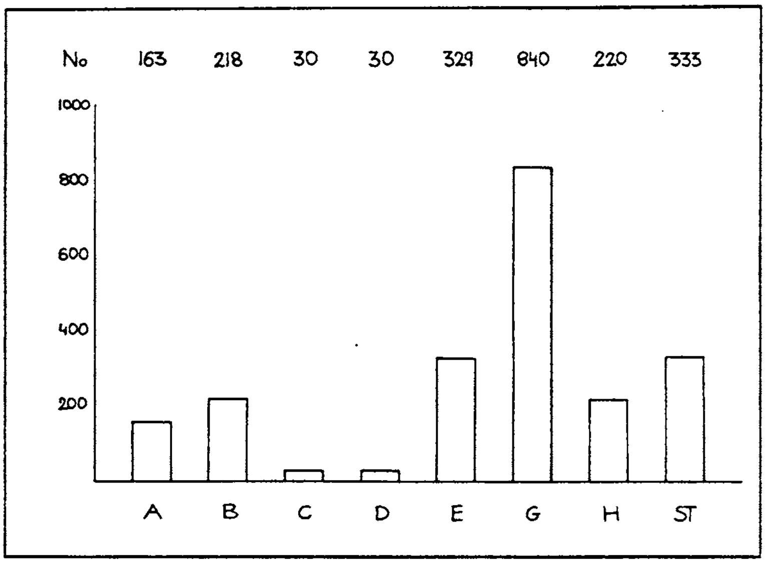

Figure 5. The mound spring sites, density of archaeological surface deposits expressed by number of stone artefacts per square metre.

The horizontal distribution of artefacts is believed to represent the imprint of human activities performed on the site. Although numerous ethno-archaeological and archaeological studies dealt with spatial (horizontal) site structure (Whallon 1973; Hayden 1979a; Spurling and Hayden 1984; O'Connell 1987; O'Connell <u>et al</u> 1991; Binford 1987c; Nicholson and Cane 1991), there is still a search for a common denominator between ethnographical and archaeological approaches. While some ethno-archaeological studies can afford to address such social issues as kin-relationship, food sharing, gender and marital status of inhabitants (eg. Whitelaw 1983:54-55; Gargett and Hayden 1991; Nicholson and Cane 1991:347), purely archaeological studies still struggle with the concept of an activity area (eg. Kent 1984, 1987a).

However, some current ethno-archaeological and archaeological studies offer more than classical analogy; they frequently provide 'experimental' data relevant to the understanding of the site formation and post-depositional processes (eg. Cane 1984; Stevenson 1991). More importantly, they can justify archaeological methods of drawing inferences from the complexity of on-site evidence (Binford 1987c:506). These studies can also facilitate a broad interpretative framework for the surface sites which do not fit into the sphere of traditional archaeological thought.

The great importance of the campsite is that it encapsulates these complex and inter-related activities reflecting life strategy of inhabitants. 'Settlement sites preserve an embarrassing wealth of information' (Clarke 1972:801). But often there is no obvious relationship between configuration of artefacts and kinds of human activities in the past. Moreover, the multiple occupation of the site and the inevitable disturbance and distortion caused by human factors and natural forces contribute to a considerable ambiguity of such a relationship (eg. Binford 1987c; Hassan 1987).

In contrast to permanent settlements, the spatial arrangement of activities such as sleeping, cooking, and food processing within the campsite may be re-defined with every subsequent camping episode (Spurling and Hayden 1984:225). While some facilities can be dismantled by the subsequent group of camping people in order to re-utilise useful construction material (eg. cooking stones), discard can be cleared and disposed elsewhere (eg. on a site periphery Binford 1987c; O'Connell 1987; O'Connell et al 1991). However this interference with the spatial pattern of a site may begin when the first inhabitants are still present on the site. With any prolonged period of camping some spatial re-arrangements of activities are made in response to changing climatic, subsistence or social factors. For example, a heat-wave may force maintenance activity to be moved under the shade of shelter or a shrub; people arriving or leaving can cause some spatial re-organisation of the camp (eg. Binford 1987c:29). It is likely that after many episodes of occupation, the spatial arrangement of any particular camping event will be blurred beyond recognition (eg. comment by Keeley 1991).

3. Mound spring sites as habitation sites

There are three sets of evidence suggesting that the mound spring sites are habitation sites. Firstly, strong circumstantial evidence consisting of geographical characteristics of the region, location of spring sites, and other archaeological sites in this area. Secondly, a number of features associated with mound spring sites that can be read as evidence of camping. And thirdly, that some technological features, density of scatter, and artefact structure point to the habitation character of the mound spring sites.

The mound springs country is a gibber plain characterised by harsh climatic conditions with extremely low rainfall and scarce, erratic appearance of surface water. The network of mound springs provide the only permanent source of water in the area. These factors must be taken into consideration for any human settlement. Post-contact history of the region provides a clear illustration of dependence on the springs for water. From the early days of non-Aboriginal settlement, pastoral homesteads, overland telegraph posts, and railway stations were established near mound springs, often bearing the name of that spring (eg. Stuart Springs, Strangways Springs, Hergot Springs). The only settlement not associated with a spring was Finniss Springs station and mission established in the late 1930's (the name was borrowed from the larger holdings set up at the Finniss Springs in 1859). This settlement, of up to about 70-100 Aboriginal inhabitants, has water supplied from the dam and several large ground tanks.

However, a long drought in late 1950's forced occupants to abandon the settlement and the mission was closed in 1961 (Mattingley and Hampton 1988; Florek 1989a). This is an instructive case showing how the Aboriginal population was marginalised and forced out of the springs which provided the vital resource in the area. It also shows that prolonged settlement away from the springs was not possible even with the aid of technology not available to pre-contact inhabitants of the mound springs country.

These geographic factors and natural conditions of the area suggest that sites located near the mound springs are primarily the habitation sites associated largely (though not exclusively) with dry periods. An argument supporting this supposition will be developed later. At this stage it should be noted that there are numerous non-spring sites within the study area. By virtue of their location away from the permanent water these sites suggest that the waterless gibber plain was visited by people in short wet intervals.

The mound spring sites are many times larger and have a much denser scatter of artefacts than other sites in the area. If the size and the amount of material somehow reflects the duration of site usage, it can be argued that spring sites were occupied for a much longer period (meaning total, added duration of single occupational episodes, and/or larger groups of people) than non-spring sites. Spring sites are relatively rare (parallel to sources of water) and there are less than 30 spring sites recorded in the area (24 recorded by Hughes and Lampert 1985; see Florek 1989c). In contrast, there must be many hundreds, if not thousands of non-spring sites in the region. During cursory exploration of a small area of 25 km section along the east margin of the Morris Creek alone, 40 sites were observed. This disparity in number in favour of non-spring sites and in amounts of artefacts in favour of the spring sites suggest that habitation away from the springs was highly dispersed. This settlement was not bound to localised sources of water, and it was of a short duration only, due to its association with relatively short rainy periods. On the other hand, the mound spring habitation was highly localised, bound to a specific water source and longer, in accordance with extended periods of dry conditions.

Several features of mound spring sites can support the habitation character of these localities. Fireplaces are the most common and visible facilities that can be related to camping activities (eg. warming, cooking, crafts, social gatherings). The best preserved fireplaces are those where heat-retaining (cooking) stones were used. Although such facilities can be found within both spring and non-spring sites, they are common among mound spring sites and rare among non-spring localities. This again may reflect a different duration of camping in different settings and probably a low incentive to construct more labour-consuming facilities in transient or short lasting campsites. Although use of fire is known in the quarry sites, hearths with heat retainers are absent (or perhaps extremely rare), attesting to a strong association of fireplaces containing heat-retainers with habitation activities.

Grinding stones are commonly made of indurated sandstone and quartzite. While handstones are often made of quartzite pebbles, a material common in the area, grinding bases are made of fine grained sandstone slabs that cannot be found near the spring sites and which were probably transported from the ranges south of Lake Eyre, from Anna Creek area to the west or Innamincka to the north-east (McBryde 1987, 1992). These heavy implements were usually left on the habitation sites, rather than being transported every time when people shifted from one camping sites to the other. Size, raw material, use and spatial distribution of seed grinders indicate the degree of planning and organisation involved in the use of the implements and related food resources. The use of seeds that need to be ground before consumption is time consuming and a low return venture. Small seeds of various grasses are especially difficult to collect in sufficient quantity and grinding, especially hard acacia seeds, requires a considerable investment of time and energy (Cane 1984:78-79;

Smith 1988:33-36). In this light, it appears that seeds were a less preferable resource, utilised mainly as an emergency food in times of food shortage and stress of the dry periods. While seed grinding implements are common features of the mound spring sites, they are very rare at the non-spring sites. This fact is in accord with non-spring sites being used in the time of plenty when easy food-stuff was utilised in the back country away from the springs. Spring sites, on the other hand, were used as retreats when life was becoming tough and consumption of difficult food resources was necessary. It should also be noted, that the time consuming occupation of seed collecting and preparation is difficult, if not impossible, to pursue in a transient camp. So, it appears that seed utilisation has to be related to a long occupied campsite (compare Smith et al. 1991).

The food refuse is a good indication of a habitation site. 'There is a direct association between food consumption and the settlement [...]; it may be taken as the archaeological rule that waste is tied to settlements' (Shawcross 1972:590). Highly fragmented macropod bones and pieces of emu eggshells attest to the habitation character of mound spring sites.

Finally numerous pieces of ochre are commonly found on many mound spring sites. Although ochre is usually thought to be associated with sacred activities it is also used in domestic context for colouring implements and body painting (Nicholson and Cane 1991).

4. Spring versus non-spring campsites

The dichotomy between spring and non-spring sites provides one of the crucial elements in the argumentation for the model of the life-strategy exercised by the inhabitants of the mound spring country.

A prediction regarding the distribution of archaeological sites was tested by Hughes and Lampert (1985) during the first systematic survey of mound springs in 1984. They demonstrated that large camping sites containing immense numbers of stone artefacts are associated with all but a few active springs. Hughes and Lampert did not provide quantitative data to demonstrate the contrast between the spring archaeological campsites and other, small campsites located away from the springs.

However, comparative data is available from the Roxby Downs area, 130km south of the mound springs network (Hughes 1981a; 1981b; Hughes and Hiscock 1981). Table 1 provides a summary of data for the mound spring campsites and for the sites of the Roxby Downs area. The contrast is expressed by the average size of the site, density of artefacts, and estimated total number of artefacts per site.

Table 1: comparison between the archaeological sites from the area of the mound springs and Roxby Downs

REGION	MEAN SITE AREA $1m^2$	MEAN ARTEFACT DENSITY no./$1m^2$	ESTIMATED NUMBER OF ARTEFACTS PER SITE	N
mound springs	20,573.9	100	2,620,840	24
range:	(375-250,000)	(25.5-300)	(10,000-3,000,000)	
non-spring sites				
Phillips Ponds to Purple Downs	375	3.8	1,425	18
range:	(60-2,000)	(0.1-20)	(18-16,000)	
Whelan Shaft area	335	0.55	185	27
range:	(10-1,500)	(0.003-1)	(3-1,500)	
Olympic Dam to Purple Downs	170	2	340	41
range:	(100-300)	(0.4-2.5)	(35-380)	

Source: Hughes 1981a, 1981b; Hughes and Hiscock 1981; Hughes and Lampert 1985.

The contrast shows that mound spring sites are between 54 and 121 times larger with the artefact scatters between 26 and 181 times denser, and the total number of artefacts is between 1,839 and 14,166 times greater than non-spring sites.

A small sample of non-spring campsites obtained in the course of my research suggests that these sites in the mound spring country, but away from the springs, often cover the area of 35 to 500 $1m^2$; with a density ranging from less than 1 to 30 artefacts/$1m^2$, and a total number of artefacts ranging from 300 to 8,000 (sites with less than 300 artefacts are difficult to identify as habitation sites) (Florek 1989c).

In general large sites containing huge numbers of stone artefacts are commonly interpreted as campsites, resulting from many occupational episodes. Such campsites are usually located on sand dunes in the vicinity of water (at least ephemeral). Other large sites located away from water are only quarries and workshops associated with the rocky outcrops. If there is evidence of habitation it is sparse as in the small sites. Small sites are frequently defined as short activity areas or transient camps or a combination of both (Hughes and Hiscock 1981; Hughes and Lampert 1985; for interpretation of sites and related activities see Hayden 1979; Cane 1984; Anderson and Robins 1988; Nicholson and Cane 1991).

Archaeological signatures of campsites encompass several components. Different authors suggest a variety of maintenance tools, cleared activity areas, food processing facilities and tools, cooking and storage facilities, food remnants, secondary refuse dumps, communal areas, campfires and shelters (Peterson 1971; Hayden 1979a; Gould 1980; Stockton 1981; Cane 1984; O'Connell 1987; O'Connell et al. 1991; Nicholson and Cane 1991). A short, single camping episode may not produce enough material for archaeological identification (eg. Gould 1971; Spurling and Hayden 1984; Anderson and Robins 1988).

Binford (1987c:498) defines the habitation site by its primary function which is maintenance of the domestic unit, other activities being secondary and in the spatial sense often peripheral to the 'household' shelter. Because habitation structures are rarely preserved in archaeological surface sites, it may be useful to summarise the characteristics of habitation sites derived from Gould's observations in Western Desert (1978:823-4). He suggests that hearths, faunal remains, and seed grinders together are diagnostic evidence of occupation. The adzes and flake-scrapers made of quarried material (eg. chert and porphyry) are commonly associated with habitation sites. Waste flakes and discarded cores tend to be smaller on the habitation sites in comparison to those on the quarry sites.

Most camping sites which can be archaeologically identified, represent the cumulative effect of many superimposed camping events. This come-back behaviour is invariably stimulated by the site location with advantages such as drinking water, natural shelter, sand to camp on, availability of edible plants, wood, and stone material for flaking. In the area of this study, drinking water was the single most decisive factor in the location of campsites; sand to camp on and a local supply of stone for flaking are other, less prominent factors.[1]

The majority of camping sites in the Roxby Downs area are located on the sand dunes in the vicinity of clay pans. These pans are ephemeral, but widely spread and common sources of water. There is a systematic relation between distribution of campsites and sand dunes/clay pans. Where a sand dune is near a clay pan, there is high probability that an archaeological campsite is located there. The campsites in the Roxby Downs area are widely spread over the sand dune/clay pan landscape, but they are significantly smaller than mound

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[1]. Sites cannot be related to presently observable local food resources because vegetation has been modified since the introduction of exotic fauna and flora, and intensive pastoral activities.

spring campsites.

In contrast, there are few dunes in the mound spring country. Sources of drinking water are permanent, but there are only 40 springs, limited to the narrow belt following an edge of the Great Artesian Basin. These few sources of water provide an obvious focus for occupation and the come-back behaviour was clearly set up by this geographical feature. A cumulative deposition of artefacts contributes to the high density and unusual richness of the mound spring campsites. This is contrary to the general trend of low density scatter of stone artefacts recorded on the sites in arid Australia (White and Peterson 1969; Maynard 1980; Smith 1987; Nicholson and Cane 1991).

The location of sites of different categories is an archaeological (and geographical) expression of the behavioural pattern of land use: the dynamics of occupation and subsistence strategy. Some aspects of this behaviour can be clearly inferred from the combination of environmental and archaeological evidence; some can be tested by quantified archaeological data.

The aim of this research is to investigate some aspects of such a behavioural pattern imprinted on the mound spring campsites. One quality, especially distinctive of the mound spring sites, is an unusual abundance of stone artefacts (Fig. 5, p.54). A similar profusion of artefacts, but of a clearly different kind, can be found only within the stone workshops usually located near quarries. This suggests that mound spring camps were occupied in an extremely intensive manner. In contrast to many non-spring sites (in the mound spring country and Roxby Dawns alike) the mound spring campsites appear to contain deposits from thousands of camping episodes superimposed one on another. In order to express this intensity, a comparison is made to one of the few ethnographic examples that are available.

Recently occupied sites, Ngaru and Walu in the Western Desert provide rare comparative data. These camps were inhabited in the mid-1940's, for 2 and 3 weeks respectively and they yielded a small number of stone artefacts; Ngaru 96 with density $2.00/1m^2$, and Walu 81 with density $1.06/1m^2$ (Hayden 1979; Spurling and Hayden 1984). Such small samples do not reliably reflect the kinds and proportions of stone artefacts and spatial patterning of established camps, but they are the best quantified examples of camping activities at a time when traditional stone implements were still in use.

In comparison to sites such as Ngaru and Walu the average mound spring campsite can be visualised as many thousands times larger. That is like 27,300 to 32,356 Ngaru or Walu camps packed tightly into the area of 143x143 metres, with an average superimposition of 316 times per every square metre of the site.

Because Ngaru and Walu were small camps, occupied by four and five people respectively, the above illustration suggests a very unrealistic picture. If the rate of stone artefact accumulation for these two sites is extrapolated for a larger group of 30 people (juveniles and adults), the average mound spring site would be an equivalent of about 2,344 camps lasting 30 days each on average, 60 days a year for 1,172 years, or 120 days a year for 586 years.

It may be tempting to use the above estimation to infer at least crude numbers regarding chronology or even the population of the mound springs. However, such an attempt would be totally unjustified. Even a slight modification of the initial data would have far reaching consequences for the number of years, peoples, and days camped on the mound spring site. Ngaru and Walu provide the only quantified, but desperately small and unrepresentative sample. For instance, no wooden implements were made within these sites due to the lack of suitable wood near Ngaru and absence of appropriate stone material near Walu. If some woodwork was performed, or if one extensive core reduction episode had taken place within these camps, the total number of stone artefacts may have been easily increased two, four, or even ten times.

On the other hand the quantity of stone artefacts recovered from Ngaru and Walu have been recently questioned. Comparable data from other Western Desert sites and lack of correlation between faunal remains and activities described by the Aboriginal informants suggest that the stone artefacts may have resulted from several occupational episodes rather than single camping event as was accepted by Hayden (Nicholson and Cane 1991:347-348). If this was the case the calculations must assume much smaller numbers of artefacts as original discard from single and short camping event. Conservative estimation would suggest that average mound spring site may be comparable to 100,000 short camping episodes such as Ngaru and Walu (assuming still much higher number than rate of discard recorded by Nicholson and Cane 1991).

The only reason for attempting the above calculation is to provide an impressionistic picture of the intensity of occupation at the springs by translating 2.6 million stone artefacts into a speculative number of people, days and years.

5. Chronology of the mound spring campsites

A. circumstantial evidence.

The mound spring sites are "par excellence" surface archaeological deposits which, by and large, were never buried in the natural sediments. This geomorphic position, on the surface of (usually the youngest) landforms provides the most immediate clue to the chronology of spring sites. There are only a handful of sites that are partially buried by very young aeolian landforms (eg. Old Woman site G, Emerland Springs). Another clue is the archaeological contents of the sites, represented largely by the type of implements that are associated with late Holocene or about the last 5,000 years of prehistory. These implements are backed blades, seed grinders, and pirri points which are conspicuously absent from pre-late Holocene deposits elsewhere in Australia (e.g. Tindale 1957; Mulvaney 1969, 1971, 1975, 1987; Mulvaney et al. 1964; Lampert 1981; Lampert and Hughes 1988; Smith 1986, 1988). Tula adzes are, possibly, confined to the last 1000 years (Johnson 1979; Hiscock and Veth 1991:342).

While there is no doubt that the bulk of archaeological material on the mound springs is associated with late Holocene, there are some circumstantial indications that this material is related to the youngest section of late Holocene rather than to the older. In other words, it is likely that the majority of the archaeological material was deposited in the last two thousand years rather than earlier (AD rather than BC).

It is known that mound spring sites were still used by Aboriginal people in late 1850's. Early explorers encountered Aborigines on many occasions. The following excerpts from J.M.Stuart's journal provide adequate examples. 'There are numerous tracks of natives about the creek; we have also seen three fires three or four days old' (Stuart 1865:66). 'Native tracks about [...] we are passing old fires constantly' (1865:74). 'Saw some natives walking along the valley [...]; I hailed them, and an old man came up to us' (1865:86). 'Saw a number of holes where the natives had been digging for water. Cleaned out one, and found water at two feet from the surface, (1865:105). The recent use of the sites is also documented by archaeological evidence.

On some sites I observed very tight clusters of flakes, a small knapping floor, clearly resulting from a single flaking episode. They are most visible on the sites' periphery which are often associated with slope. Clusters located on the dune slope are subject to rapid dislocation by the force of gravity in conjunction with wind and water. In spite of this disturbance-prone position, many of them are minimally upset by the 'slope effect' (Photo 5). I noted also some fireplaces preserved in perfect condition on the surface of a dune. Among them were hearths filled with soft charcoal powder. Yet surprisingly, there was minimal infiltration of this material into the underlaying sand stratum. In some fireplaces I saw relatively large fragments of broken animal bones, which are generally very poorly preserved in local sandy sediments.

Rare traces of the traditional use of non-Aboriginal material, such as metal or glass, can also be noted. I saw glass that had been flaked and used as scrapers at Strangways Springs Telegraph Station (Florek 1988b), but this material must be attributed to a post-contact period. Glass is also conspicuously absent from two other sites located within a half kilometre of the station.

Similarly, bones of introduced animals are absent from the mound spring assemblages. Some intrusion of bones from introduced animals are clearly associated with non-traditional, post contact activities and often, plainly with domestic rubbish being dumped on the site (eg. Florek 1988a). This evidence is in accordance with inferences that can be made from oral records, written documents and historical archaeology (Dean Fergie pers. com. 1989, 1990). These documents clearly show that the rapid influx of European settlers to the mound spring country in the late 1850's and 1860's forced the local Aboriginal population to abandon traditional camping sites near the springs. These locations became focal points of white settlers and their economy. Therefore, the traditional occupation of mound springs ended abruptly in the 1860's.

The question that needs to be answered is how far back in time this settlement of the mound spring country extends, or more specifically, what is the period of origin for the MAJORITY of the archaeological material associated with occupation of mound spring sites ? In the context of this research, a focus must be given to a time frame of deposition of the bulk of archaeological material rather than the oldest traces of human presence at these locations. It can be assumed that the largest share of archaeological material currently present on the spring sites was laid down as a result of their continuous intermittent occupation.[2] This occupation should have a chronological boundary. Its abrupt ending in the middle of the last century is well documented. Commencement of this occupation must not be earlier than 5000 years ago (Hughes and Lampert 1985:17-18). A review of some geomorphological evidence from the springs and the entire area, suggests that the beginning of this settlement can be attributed to an even younger date.

The geomorphological history of the mound springs is not well understood, but some aspects of mound location, size, morphology, and spring activity can be used as crude chronological indicators.

The mound springs can be grouped into two categories: Pleistocene and post-Pleistocene (or recent) springs. The Pleistocene springs are all extinct. Prominent mounds such as Beresford Hill and Hamilton Hill rising 30-40 metres above the surrounding plains originated in the Pleistocene, about 80,000 years ago. They developed under a different hydrostatic regime (Jessup and Norris 1971; Habermehl 1982a, 1982b, 1983). Well pronounced sedimentation of gypsite and formation of freshwater limestone and travertine took place at the same time. About 30,000 years ago Lake Eyre was significantly depressed simultaneously with the considerable uplift of the area west of the lake. These events triggered extensive dissection of the gypsite sediments, in places removing 30 metres of the deposits down to the current flood-plains. Towards the end of Pleistocene some additional minor uplifts took place which are documented by further rejuvenation of a drainage system (Wopfner and Twidale 1967:141). Pleistocene springs probably became extinct before that time. Built of the compacted travertine, some of the Pleistocene mounds survived as the remnant of the older erosional surface.

If any traces of possible human occupation were deposited

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[2] Arguments for this assumption such as geographical condition, spatial pattern of archaeological deposits, and structure of assemblages are developed in chapters IV, V and VII respectively.

in these spring's vicinity they must have been displaced and dispersed with many metres of the sediments which once wrapped the slopes of the Pleistocene springs. If such remnants were incorporated into the travertine itself, this would be likely to occur when the springs were active, that is close to 30,000 years ago or probably earlier. If such a lucky event took place those remnants may one day be recovered by archaeological methods.

The significant feature of the Pleistocene springs is that they are all located much higher above the recent erosional plane than current active springs. This provides the most general and obvious evidence to chronological relation between Pleistocene and younger springs (Boyd 1991).

The recent mound springs of post-Pleistocene origin can be divided into three groups. Each group represents a different stage of spring development and by inference different antiquity.

Recent non-active mound springs are characterised by a thin travertine coat covering softer gypsiferous silt. There is much evidence of deterioration and weathering. These springs are 2-3 metres high, 15-18 metres wide with the slope gradient 20-25 degree. Such mound springs are uncommon and they represent the oldest generation of the 'recent' mound springs. Thomson and Barnett (1985:26) made the following comment: 'Since cessation of flow, the mounds have suffered severe weathering and erosion and it appears that [...] the Recent mound springs are ephemeral landforms.' It is likely that the small number of non-active springs reflects their short existence and that many may have been completely eroded. The archaeological deposits were never observed in clear association with those non-active springs.

Waning mound springs are frequent in the area. The mounds are well developed with hard travertine coat covering gypsiferous silt and display varying degrees of weathering. The vent is usually closed and water is present only as seepage below the middle of a slope. They stand 3-4 metres high, are 15-18 metres wide with the slope gradient 10-25 degree. Waning mound springs represent the immediate past generation of springs. Thomson and Barnett (1985) attribute the loss of activity to the overall lowering of water pressure in the Great Artesian Basin. The artesian bores sunk into the aquifer during the last hundred years contributed to a significant reduction of the water flow from the springs.[3] Together with the reduction of water flow 'disintegration and decomposition of the mound by weathering is beginning to occur' (Thomson and Barett 1985:19). This provides a glimpse of how quickly destructive forces can obliterate mound springs. While archaeological deposits are present in the vicinity of these springs it must be made clear that these springs are commonly found in clusters with the youngest generation of recent active mound springs.

The recent active mound springs are characterised by poorly developed mounds and the presence of a pool of water or overflow channels. They are from 1 to 4 metres high, the majority are 5-12 metres wide and slope gradient varies between extremes of 2 and 35 degree. In the study area about 20 springs and spring clusters fall into this category. These springs are the youngest.

Although it is not possible to demonstrate exclusive association of archaeological sites with the youngest (recent active) springs as they are often mixed with waning springs, it is clear that archaeological sites are near active springs discharging substantial volume of water.

The mound springs, at least under the hydrostatic regime of the Holocene, can be seen as outlets of artesian water which tend to shift fairly frequently from one spot to another in specific local spring activity areas. These activity areas are commonly located within a creek channel. For example, in the Hermit Hill area (Finniss Creek channel) there are about 40 springs, but only several discharge visible amounts of

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[3]. However Boyd (1990:112) maintains that there is no convincing evidence of the overall reduction of water discharge, apart from lower output of springs affected by local artificial bores and industrial pumping.

water. However, there are probably several hundred smaller and larger mounds of the extinct springs, many having dried-out in an early stage of development (documented by their small size and lack of travertine coating). This attests to frequent shifts of water outlets and consequently the constant re-dressing of a local landscape. Recent cessation of shifting outlets can be attributed to the overall lower pressure in the Artesian Basin caused by many artesian bores and some industrial water pumping (eg. for Roxby Downs and Coober Pedy).

These small dry mounds attesting to frequent shifts of the water outlet probably eroded rapidly. J.M.Stuart often reports seeing such formations in his journal of 1859. Referring to the springs he saw from a distance: 'instead of two, they are numerous all round the hill, some are without water on the surface, and others have plenty. It is a perfect bed of springs. A little more east they are stronger, surrounded with green reeds and rushes. [Later he] came to a large bed of springs with reeds and rushes, water running and good, with numerous other small springs all round' (1865:84).

It has been calculated that an average spring can deposit about '170 tonnes of calcium carbonate in 1,000 years, enough to built a hemispherical mound 3m high' (Thomson and Barnett 1985:14). This suggests that even fully developed (but without travertine coating) recent active springs may not be much older than 1,000 years.

Since the recent active springs are often mixed in one cluster with the waning mound springs, it is difficult to demonstrate a pattern of association between these two classes of springs and the archaeological deposits. However, it is clear that all recorded mound spring sites are associated only with springs currently discharging a substantial volume of water. This circumstantial evidence can not be read as an argument for the lack of earlier, pre-middle Holocene and Pleistocene occupation of the mound spring country. Nonetheless, it indicates that the bulk of material deposited on the surface sites, referred to in this research, originated in the period of time after the major re-dressing of the local landscape. It must be assumed that this period witnessed relatively little spring shifting and re-arrangement of ephemeral landforms such as local small sand dunes and sand-sheets. This should be read in the context that dune building forces responsible for development of the current dunefields in the Lake Eyre Basin are intrinsically Holocene phenomena still active in re-dressing geomorphic landscape of the region (Twidale and Wopfner 1990).

The rapid re-dressing of local landforms can be illustrated by a small dune in the Old Woman Springs area (site G). The dune has probably developed as the result of a 'new' spring being established on a slope of current waterway. Vegetation near the spring possibly trapped aeolian sand which gradually became stabilised by plants encroaching on a dune (Photo 4). The upper half of the dune, bearing archaeological material, produced the radiocarbon date 430 +/- 110 BP (SUA:2683). Dune development must have partially overlapped with human occupation as a large portion of artefacts is buried in the sandy deposits. Buried quartzite flakes (that have been produced on the site) have sharp edges and rough surfaces in comparison to the flakes found on the dune surface.[4] Sand blasting responsible for smoothing of the surface material has not affected earlier stone artefacts which were rapidly buried by advancing dune buildup. Probably in the last 100 years, since the spread of rabbits in the area, one third (approximately 60-70cm) of the upper part of the dune deflated and this process continues at the rate of about 2-3cm per year. In the next two hundred years the dune could be totally erased from the landscape (Photo 6).

Redressing landscape and shifting water outlets can also be inferred from the chronology and floral history of

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[4]. This feature is very distinctive but difficult to measure. Experimental flaking of local quartzite produced flakes similar to excavated specimens with sharp edges and rough surfaces.

Dalhousie Springs. A sample of peat deposit, expected to be 5,000 or 10,000 years old, is dated only to 2,000 years BP. One metre of organic mud is deposited directly on Cretaceous Bulldog Shale suggesting that possible older spring deposits were eroded in a course of frequent changes of the local landscape. In the pollen profile the abrupt change in plant communities is associated with sharp increase of charcoal at about 400 years BP. This can be tentatively attributed to human activity within the springs area (Boyd 1989:21).

Archaeological material on the mound spring campsites consists of surface and shallow sub-surface deposits. The artefacts from the early and late phases of the site occupation are mixed together in a thin horizontal plane (c. 5cm). The artefacts buried to a depth of 50cm or more, are related to the very young sandy landforms (eg. Old Woman site G). Older, well developed dunes have a hard compacted core, rich with clay and gypsum. Development of such a hard core is a slow process which requires several thousand years. When an archaeological deposit is found on such older landforms, it never extends into this old well developed stratum.

Fireplaces and their debris are common on the sites. In most cases, the youngest fireplaces are well preserved. The older fireplaces were often disturbed by latter occupations and by wind and water erosion. The older hearths contain very little or no charcoal at all. This suggests that most of the fireplaces were exposed on the surface and therefore easily eroded. Stone heat retainers were commonly used in the area. They were no doubt especially needed during long cold nights and when firewood was in short supply. Ethnographic evidence shows that heat retainers were also used for cooking, especially for large game such as kangaroo or emu (eg. Tunbridge and Coulthard 1985:19). The interpretation of archaeological evidence indicates that it was common practice to remove the cooking stones from older fireplaces (unless they were shattered to pieces) and put them in the new one. It suggests that occupational episodes followed each other in a short span of time. On the surface sites fireplaces are practically the only potential source of organic material suitable for dating.

B. Radiocarbon dating.

During the course of this research five radiocarbon dates were obtained from four different spring camps. Four dates are based on charcoal samples using conventional dating techniques and one on the Accelerator Mass Spectrometry (Table 2). These dates are distributed within the last 900 years (compare Table A1 in Appendix).

Table 2: radiocarbon dates

laboratory number	collection unit	radiocarbon date BP	site name
Wk - 1731	D/Fa/90	860+/-65	Davenport D
Wk - 1730	ST/F1/90	560+/-75	Strangways ST
SUA: 2683	G/28/35	430+/-110	Old Woman G
NZA 723*	G/29/34	273+/-70	Old Woman G
BETA-31500	GC-F1	80+/-50	Old Woman GC

* accelerator mass spectrometry result.

The archaeological contexts for these five samples are described in the following paragraphs. Each case illustrates a specific situation but most are commonly encountered on the mound spring sites.

Site Davenport D.

The oldest date, 860 +/- 65 years BP (Wk-1731), was obtained from a well-preserved fireplace partially buried in the clay loam soil. The fireplace was a 20cm shallow pit, 50cm in diameter. The pit was filled with heavily burnt soil, pieces of charcoal scattered throughout and about 10 kilograms of cooking stones. Some cooking stones were visible on the surface and partially dispersed around the fireplace. The contents of the soil, as well as the stone retainers indicate that the fireplace was an efficient heat-retaining facility.

Because of an ample supply of stone on this site, there was no strong incentive for its occupants to dig up the old fireplaces to recover old retainers. The high content of silt and clay has made this fireplace hard and compacted, contributing to its good preservation.

Site Strangways ST.

The second oldest date, 560 +/- 75 years BP (Wk-1730), is for a highly disturbed fireplace partially buried in a soft sandy deposit, with rich intrusions of calcium carbonate, 20cm below the surface. This fireplace was marked on the surface by a partially dispersed cluster of heat retaining calcrete stones. As stone is virtually absent in this area, and must have been used sparingly and recycled whenever possible, it is likely that stones from this old fireplace were used in the younger fireplaces which are present on the site. They contain a large number of the calcrete stones and are filled with baked sand and ample amounts of pieces and powdered charcoal. The fireplace dated contained only a few stones. However, the lower part of the hearth was left intact, marked by the well defined shape of baked sand and a sparse scatter of charcoal.

Site Old Woman G

The intermediate date, 430 +/- 110 years BP (SUA:2683), is from pieces of charcoal scattered within 1 sqm between 55cm and 80cm below the top-dune surface (soil volume 0.25m3). This was the lowest level bearing an archaeological deposit, containing stone artefacts, pieces of ochre and fragments of burnt macropod bones. There are no discernible strata in the sandy deposit of the dune. In theory, this sample of charcoal should pre-date all archaeological material above it. In sandy deposits, however, considerable vertical movement of objects can occur (Villa and Courtin 1983; Hofman 1986). The relative position of material along the vertical line need not necessarily provide reliable indication of the relative age of those objects. It follows that samples from the bottom part of the archaeological deposit, may not be the oldest evidence for occupation of this site.

It is possible in such circumstances that charcoal is not related to human activities, but may be of a natural origin (eg. a bushfire). However, some taphonomic observations on this site suggest that all light material such as small bone and shell fragments, small stone flakes and shatters tend to be blown away by wind rather than accumulating on the site. While such a sample needs to be considered with caution, it should be noted that the above date fits comfortably with other dates obtained for the mound spring sites.

Site Old Woman G

Another date, 273 +/- 70 years BP (NZA 723), was obtained from a charcoal sample collected from a fireplace. It was superficially buried in the sand. The fireplace was a well-defined structure with 25 kg of heat retaining stones arranged in an oval 50cm x 70cm in area. A small (25cm x 25cm) patch of baked soil was present in the middle with pieces of charcoal scattered throughout, to a depth of 15 cm.

Site Old Woman GC

The last date, 80 +/- 50 years BP (BETA-31500), is for a charcoal sample collected from a very well-preserved fireplace on the low sandy dune. This fireplace consists of a regular 85 cm circle of hard lumps of baked soil, large fragments of charcoal and relatively large fragments of burnt animal bones. It was covered with only a very thin sheet of sand. Similar, well preserved fireplaces can be found on many mound spring campsites. Dating one of them suggests that these well-preserved fireplaces are often the youngest on the site. They seem to be undisturbed, either by the episodes of later occupation or by natural deterioration, only erosion has begun to affect them.

It seems that both the conventional date (80+/-50 years BP) and the calibrated date (about 53 years BP) are too young (compare Table A1 in Appendix). However Val Attenbrow (Australian Museum) drew my attention to the fact that if the lowest range of this date is considered (80+50= 130) it would indicate the year 1860 AD. In the light of historical accounts the traditional Aboriginal occupation of the mound springs ended abruptly at that time.

The small number of dates presented here does not preclude the possibility that the mound springs occupation can be traced much further back. Indeed, there is evidence that human presence in this part of Australia stretches to at least late Pleistocene and early Holocene (Lampert and Hughes 1988; Veth and Hamm 1989; Veth et al. 1990; Smith 1989; Smith et al. 1991). However available evidence suggests that at least the bulk of archaeological materials on the mound spring sites have been deposited within the last 1,000 years (this can be asserted by the integrity and coherent structure of assemblages, issues explored in chapters V, VI, and VIII).

Dateable evidence suggests that the spring sites cannot be ordered in any chronological sequence. Many young and well-preserved fireplaces that can be found on most of the sites were not dated because of the prohibitive cost. However, they attest that occupation of the campsites continued until the middle of the last century when it abruptly ended due to a sudden influx of white colonists.

The beginning of this late Holocene occupation is not reliably established but circumstantial evidence combined with the dated samples, suggests that the bulk of archaeological material on the mound spring sites was accumulated within the last several hundred years. The beginning of this deposition can be tentatively placed at about 1000 years BP.

It is instructive to discuss the mound springs chronology in a broader perspective. For over a decade extensive archaeological fieldwork has been carried out in various parts of the Australian arid core, much of it with the explicit aim of discovering evidence of Pleistocene occupation. Although the human presence in this part of the country by 22,000 BP has been established (Smith 1987, 1989), there is an uncomfortable disparity in nature and quantity between Pleistocene and late Holocene archaeological evidence.

There are only several sites documenting Pleistocene occupation of the central and eastern portion of central Australia. In the semi-arid far north there are Colless Creek (20,000 BP) and Cuckadoo (15,000 BP) rock shelters. Puritjarra rockshelter (22,000 BP) in the Cleland Hills is about 900 km north-west of the study area; Koonalda Cave (22,000 BP) and Allen's Cave (20,000 BP) are about 700 km west near the head of Great Australian Bight.

Closer to the area of this study are: Hawker Lagoon in Flinders Ranges dating back to 15,000 BP (Lampert and Hughes 1988); JSN site in the Strzelecki Desert with the oldest date 14,400 BP (Smith et al. 1991), and; two sites from lower Cooper Creek dated to 12,000 BP (Veth and Hamm 1989; Veth et al. 1990). These are the only open sites of the Pleistocene age in the central arid core of the country. In the vast area around Lake Eyre there are no caves or rock shelters although at least several hundred open sites must have been inspected and some were tested by archaeological methods.

In 1968 Stockton excavated Kurringke, an open site in the Ooraminna Ranges in central Australia. Archaeological material deposited to less than 1m below the surface has been dated to 1,000 BP (Stockton 1971; Smith 1983). Since then nearly every open site tested in the central arid core turns out to be no older than 5,000 years and most sites are younger than 3,000 years (eg. Williams 1988).[5] The late Holocene age of the majority of open sites was well demonstrated by intensive fieldwork in the upper Cooper Creek area. Here five dates range between 300 and 3,000 years BP (Williams 1988). It is worth noting that several rock shelters in central Australia produced dates confined within the last 5,000 years (Smith 1983, 1988). Further afield, similar pictures emerge from exploration of rock shelters in the Rudall River region of Western Australia. Veth (1989:88-89) provides a series of five dates ranging between 300 and 5,000 years BP.

Such evidence lends support to various speculations concerning timing and occupation patterns of arid core of Australia. The often circulated model assumes incidental intrusion of human population into the area throughought late Pleistocene, with retreat at the peak of glacial aridity (Lampert and Hughes 1987; Smith 1989), and finally proliferation of human groups and rapid population increase in late Holocene (eg. Gould 1977; Bowdler 1977; Lampert and Hughes 1980, 1987; Veth 1989; Williams 1988).

The alternative hypothesis has been contemplated (Smith et al. 1991:190) and this suggests that there may not have been significant population decline or retreat of inhabitants during the Pleistocene climatic changes. To make such an alternative credible one needs to reconcile the scarcity of evidence related to Pleistocene and early Holocene occupation with an abundance of evidence for late Holocene. In reference to Central Australia Smith (1983:36) made the following

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[5]. Rare exceptions are Balcoracana Creek and Big John Creek dated to early Holocene (Lampert and Hughes 1988:148), and some, not directly dated early Holocene deposits at Dalhousie and West Finniss Springs (Lampert and Hughes 1987:30). The earth oven excavated on site B, Welcome Springs, has been dated to 6,900 +/- 550 (TL dating). This oven is 20 cm below the surface and stratigraphically separated from stone artefacts on the site surface and in subsurface position. While this oven indicates earlier human presence in the area it cannot be related to the surface assemblage characterised by backed blades, tulas, and thumbnail scrapers.

comment: 'the main implication for fieldworks is that sites older than 5000 years are probably deeply buried in this area.' Williams (1988) suggest that the absence of Pleistocene sites in the Coongie Lake system may be explained by the fact that associated dunes are of late Holocene origin. Archaeological material found on the surface of Pleistocene sediments was always derived from younger, Holocene landforms. Lampert and Hughes (1988) recognised some re-dressing of landforms associated with slope formation in Hawker Lagoon. Massive erosion activated by recent clearing and agricultural activities was also investigated on this site (Cameron et al. 1989). My own observations on the mound springs, along lower Finke River, in the lower Cooper Creek area, and in the Channel Country suggest extremely rapid changes in local landforms and often wholesale destruction of archaeological deposits.

In light of this evidence, rarity of sites older than mid-Holocene appears to be largely a result of the geomorphic nature of an arid environment, combined with a low relief of the country and the large areas of clastic sediments. If such a scenario is considered, some predictions concerning the nature and location of old archaeological sites can be suggested. 1) Less disturbed material will be buried deeply on localities favouring long term sedimentation (eg. Puritjarra Rockshelter); 2) The open sites likely to be intact are buried and can only be exposed by recently activated erosion (eg. Hawker Lagoon; probably CC77 and CC139 from the lower Cooper Creek); 3) The open sites exposed for a long time will be largely disturbed and/or re-deposited (eg. Balcoracana Creek, Big John Creek); 4) Most of the late Holocene sites are located on elevated landforms such as dunes and slopes (eg Hughes 1981a, 1981b, Hughes and Hiscock 1981; Hughes and Lampert 1985, Williams 1988). It may be assumed that many older sites in this area were also located on previously elevated landforms. Because such landforms are ultimately destined for destruction, associated archaeological sites must be re-deposited or destroyed. For example many late Holocene sites in the Coongie Lake area seem to be already re-deposited (Williams 1988). In effect stone artefacts may be divorced from such features as hearths (probably Balcoracana Creek) and/or sorted by size even before assemblages were buried in the ground (probably some Kartan sites).

The broad pattern of distribution of Pleistocene sites suggests that well preserved archaeological deposits are found in the ranges which provided locations favouring long term stable sedimentation (eg. Puntutjarpa in Warburton Ranges, Puritjarra in Central Australian Ranges, Hawker Lagoon in Flinders Ranges). In contrast the large area of the Lake Eyre Basin is highly dynamic and landforms favoured for habitation are subject to rapid erosion. In this context the mound spring sites can be expected to be of late Holocene origin, most likely confined to the last 3,000 if not 1,000 years.

Furthermore it must be emphasised that mound spring sites show strong structural integrity: 1) stone artefacts are associated with habitation facilities such as fireplaces; 2) the macropod bones and emu eggshells often form a substantial component of archaeological deposits; 3) assemblages usually encompass the entire spectrum of discard related to respective stone-craft and probably use of implements, including smallest chips and shatters (see chapter VII & VIII), and; 4) spatial distribution of archaeological material suggests consistent, repetitive use of the sites.

There are two implications of this integrity. Firstly, it may be inferred that current archaeological deposits at the mound spring sites are considerably younger because the degree of destruction is relatively low (with some discernible exceptions). Secondly, if spring assemblages contain some portion of older (eg. pre-late Holocene) material it must only be a small component because the assemblages show consistent structure in which different aspects of technology, tool categories, reduction and secondary modification of artefacts are manifestly co-related (see chapter VII & VIII).

6. Conclusions

When the mound springs are considered in the context of an environmental system and other archaeological records in the area, they must be interpreted as habitation sites, occupied predominantly during dry periods. Although limited attention was given to large amounts of non-spring sites present in the area (apart from site C which was sampled for this study), they appear to be linked to the mound spring sites within a common life strategy system.

Non-spring sites attest to the short forays by people into the back country during and shortly after the rains when surface water was easily accessible. Food resources that could have been procured from the back country were not significantly different from those available closer to springs, but they were not heavily depleted by humans during longer spells of drought (compare Penny and Moriarty 1978:20; Peterson 1978:26).

While potential food resources away from springs were similar to these in the area of the mound springs, there was greater flexibility and selectivity in their use. Two guiding factors were a) relatively even spread of water allowing free movement through the area, and; b) largely short periods of time allowed for such unrestricted movement, as high evaporation rate caused surface water to disappear rapidly. As a result, easily procured and high-yield tucker was targeted during rainy forays to the back country. The food stuffs obtained there could have included large game and eggs, nectar and honey, fruits, green vegetation, some tubers, and occasionally water birds and fish.

In contrast, the mound spring sites were associated with a more systematic procurement of all edible resources including seeds which required laborious processing. The use of seeds provides the most archaeologically visible distinction between the two types of sites. This is expressed by the rarity of seed grinding implements on the non-spring sites. The transient character of the non-spring sites is also reflected in a low proportion of formal tools, which are related to craft-work performed on the sites. High mobility associated with the use of non-spring sites and a certain urge to quickly procure an easily available food, discouraged engagement in time consuming crafts. Therefore, it is likely that beyond the necessary tool maintenance, little craft-work was performed in the transient camps. If craft-work, in at least a crude manner, is indicated by the amounts of formal tools on the site, then it is instructive to compare tool proportions between spring and non-spring sites (table 3).

Table 3: formal tools represented on mound spring campsites and one non-spring campsite included in this study

site	formal tools per sample %
A	4.6
B	4.5
C (non-spring campsite)	1.9
D	3.4
E	3.7
G	2.6
H	4.3
ST	3.1

Formal tools included in this table are: backed blades, scrapers, tulas, pirri points, and retouched flakes.

CHAPTER IV.
A GEOGRAPHICAL MODEL OF OCCUPATION

> 'Family groups or clans did not wander aimlessly or wherever they pleased about the country in search for food and water. [...] the people would spent most of their time in the areas of permanent waters [...] and would have only been able to fully utilise the extremes of their tribal areas during exceptionally good years'.
>
> P.K.Latz and G.F.Griffin 1978:77-78

1. Introduction

The model of occupation is described in this chapter. It should be read as a background to the archaeology of the mound spring country. The model attempts to integrate environmental evidence and the readily visible pattern of the settlement system. Its role is to provide a framework within which the research problem will be developed. In the following sections I will outline the rationale for, and the model itself. Further I will discuss its implications, which are used to formulate my research question.

It is common practice that different ways of life and their changes in prehistory are presented in the form of a model. The model is a convenient way to integrate archaeological inferences and to provide a theory of the past events which accounts for the pattern of empirical data (archaeological evidence). In other words, a model is a way of describing a "historical" process in prehistory. For example, faced with an occupation gap in the Hawker Lagoon between 15,000 and 5,000 BP, but the presence of archaeological sites dated to early Holocene at Lake Frome, Lampert and Hughes (1988) postulate the following scenario: with the early Holocene climatic amelioration Hawker Lagoon was no longer the focus of occupation, instead people were able to move to more arid areas of the country. They suggest that this was a widely spread trend of moving from better watered uplands and ranges to harsher lowlands of the Lake Eyre Basin, accounting for early Holocene population of the desert areas of this part of Australia.

It is instructive to look at some of the models proposed to explain archaeological patterns observed in the areas close to the mound spring country.

Jones (1979a) proposed a subsistence model for the central part of the Channel Country relying on the landforms, sources of water and plant communities. He suggested that people moved into the dunefields after rain, and back to the alluvial plains during dry phases. The latter habitation at permanent swamps or lakes was associated with an increase in group size.

Drawing on the ethno-historical accounts (Jones 1979b) Williams proposed a similar model for the Coongie Lake system. Here, the lake habitat provided sufficient food resources for semi-permanenent occupation; at least part of the local population stayed at the lakes year round. However, after rain when ephemeral water filled the claypans between the dunes, groups of people moved out into the dunefield to harvest small mammals, reptiles and plants abundant in sand ridges.

Research in the lower Cooper Creek area prompted the re-formulation of the original Jones' model (Veth and Hamm 1989; Veth et al. 1990). In the new model three habitats are considered: the most productive ecotone between dunefields, floodplains and Cooper Creek itself; the ecotone between dunefields and Creek which, in the absence of floodplains, provide less variable resources, and; lacking permanent sources of water, the dunefield system itself. The first habitat is assumed to be occupied in the most intensive manner, with the highest aggregation of people, between March and August. The second displays an appreciably lower intensity of occupation, with some large basecamps associated with permanent but more intermittently spaced water sources. The third, dunefield zone was only visited in rainy periods for the procurement of resources but not prolonged habitation.

It should be noted that the above models rely on environmental evidence and allocation of archaeological modules within geographical space. They assume that archaeological evidence primarily reflects scheduling human activities within the landscape and specific climatic conditions (eg. seasons, rainfall), and also that such scheduling is predominantly driven by subsistence activities.

These models are the best way to outline an historical process inferred from archaeological records. How can the models be tested ? I submit that they can be verified only by the provision of new data. Bowdler's (1977) model of colonisation of Australia is a good example. Distribution of Pleistocene sites known by mid-1970's suggested that early human population was confined to the more productive coastal regions, major rivers and lake systems, while settlement in the arid interior was largely delayed until climatic amelioration in the early Holocene. Although subsequent discoveries prompted revision of this model, it still provides a useful framework of reference. If such late colonisation of the arid core is no longer valid, the retreat of people to the better watered uplands and ranges in the most arid climatic episodes are considered (eg. Lampert and Hughes 1988; Smith 1989).

In regional archaeology model testing is attempted on two levels:

1) prediction about the distribution and character of archaeological sites in the region (eg. Hughes 1981a; Hughes and Hiscock 1981; Hughes and Lampert 1985; Wiliams 1988);

2) prediction of the settlement and subsistence system (eg. Veth and Hamm 1989).

Extensive regional studies in the arid part of South Australia assembled a sufficient pool of data to observe systematic association between specific types of landform and water sources, and types and distribution of archaeological sites. Such predictions were tested by Hughes (1981a) in the Roxby Downs area and by Hughes and Lampert (1985) in the mound springs country. Positive verification of these predictions suggests that settlement patterns in many arid regions of

Australia are well understood. This clearly applies only to the period represented by a dense data matrix, and similar to the present climatic regime, that is to the late Holocene. It also indicates that models concerning subsistence patterns of the past populations are well founded and likely to provide a valid picture of prehistory.

Testing predictions concerning settlement and subsistence systems appears more problematic at present. It is easy to fall into the trap of a circular argument. For example, drawing on the numerous ethno-historical and archaeological accounts Veth and Hamm (1989) developed an elegant model of subsistence for the Lower Cooper Creek. The model was then tested by virtually the same evidence, although extended by new field surveys and some quantification of archaeological records. One may postulate that the model can be better tested by an independent set of data such as the archaeological signature of rainy period activities in the dunefields and dry season tasks performed at the sites near permanent lakes and swamps.

However the model can best be used as a heuristic tool in re-focusing and re-formulating the research problem. Although the model provides a useful skeleton, the archaeological evidence potentially entails far greater complexity than such a sketchy framework. Based on the settlement pattern, the model depicts cyclical (eg. seasonal) transformations of a social system. However, the bulk of archaeological evidence is about something different, largely craftwork and cooking and only indirectly relates to social organisation. Hence simple testing, similar to procedures adopted in Newtonian physics, seem often impossible and largely inadequate in the provision of knowledge in archaeology.

One of the characteristics of the model is that it provides a skeletal structure which, in an explicit or 'silent' manner, helps to generate hypotheses concerning various aspects of the past social system. Some of these hypotheses cannot be explored by archaeological methods, while others can be examined and verified. Obviously part of the research is to generate testable and meaningful hypotheses, but also to prospect areas beyond existing paradigms. It seems that the best role of the model is in fostering further investigation rather than seeking its own confirmation.

2. Basis for the model

In the former two chapters (II and III), the environmental features and archaeological background of the mound spring country were outlined. These two components can be integrated into a geographical model of prehistoric occupation. In this section I will summarise the environmental and archaeological evidence.

Like other models of a similar nature, the model for the mound spring country relies on the geographical features of the area. In relation to human occupation, the rare sources of water aligned neatly along the edge of the Great Artesian Basin constitute the single, most significant feature of the land. The second important feature is the surrounding area: waterless gibber plain with sparse vegetation. It must be stressed that the gibber plain, in this part of the country, is virtually without water in contrast to many sandy desert regions where water can be retained at the base of dunes base for a long time. The Western Desert provides a good example where small soakages are scattered over the entire area; it 'is studded with thousands of these tiny waters' (Strehlow 1965:124; see also Thomson 1975; Peterson 1978; Cane 1984; Hercus and Clarke 1986). In the research area a strong contrast is expressed by the springs providing permanent drinking water and the stony desert being without water, apart from the short rainy periods.

Another geographical factor concerns the vegetation which is scattered sparsely through the country. On the whole, spring areas represent similar poor vegetation, as do the areas far away from the springs. Many plant communities are scattered over the landscape in small pockets rather than in large areas of many square kilometres. This means that while the surroundings of a spring may contain some extra clumps of mulga or casuarina and patches of grass or reeds, they are not substantially more bounteous 'oases' of bio-resources, able to sustain intensive foraging.

The environment is not static, but fluctuates in various ways. Seasonal changes are usually accentuated by very hot summers and cool to cold winters. However, rainfall is erratic, and the rejuvenation of plant communities depleted by drought is largely aseasonal. While some plants respond to minor precipitation, many need more substantial rainfall for recovery and/or further propagation. The animal population also expands and contracts in an irregular manner in response to rain and the availability of food. Many species simply migrate away in times of food scarcity.

In spite of these erratic changes in climatic conditions, there is a certain time scale to events. The rains are usually short, often in the form of scattered showers; they rarely last more than several weeks and are commonly dispersed in an uneven manner between the dry periods. (The mild climatic condition in contrast to dry times is referred to here, for convenience, as wet, but it must not be taken literally). Dry conditions, on the other hand, are common and often last for months or years. Prolonged droughts afflict a heavy toll on local biota resulting in varied successions of massive depletion of food resources.

In relation to the Aboriginal occupation, the mound spring network must be seen as a single entity (Hercus and Sutton 1985:14). There is enough circumstantial evidence suggesting that settlement in the mound spring country was possible only because of the spring network; no single spring alone would provide a substitute for this network. The main reason is the virtual lack of permanent water other than springs, and the overall poor bio-resources. In order to procure the necessary provisions, hunter-gatherers must forage over relatively large areas. In times of drought, the foraging territory was reduced to areas near the springs as further forays were forbidden by the lack of water. Although it is difficult to define exactly the area necessary for the survival of the local population, it seems that a narrow strip of land running along the spring network was barely sufficient in times of severe droughts. There are indications that some local Aborigines were moving out into neighbouring tribal lands during the most difficult times (Deane Fergie pers. comm. 1990).

Such dependency on the spring network can be inferred from the sudden collapse of the local population in the middle of last century. In 1858 the first white explorers travelled through the area (Bobadge, Warburton, Parry, Stuart; although E.J.Eyre passed through this country in 1840 it remained unexplored for another eighteen years). During the following year (1859) the first pastoral holdings were established here (eg. Old Finniss Springs, Callanna, Mundowdna, and Mount Margaret). Early in the 1860's, the whole spring country was taken over by pastoralists. The importance of the springs for opening up the country to white settlers was spelled out by Stuart in 1859: 'by the discovery of springs on this trip, the road can now be travelled to the furthest water that I saw on my last trip from Adelaide, and not be a night without water for the horses' (1865:94).

It seems that the takeover of some of the major springs in the area was a mortal blow to the local Aboriginal population which was deprived of its country in an incredibly short span of time. Accordingly, the ethnography of the local population at the time of contact does not exist beyond casual remarks made by early explorers. This is in contrast to several Aboriginal tribes further north where disruption was not so sudden. The different impact is attested to by early ethnographic studies by Spencer and Gillen (1899, 1904). While travelling through the mound springs area in 1895, they observed that 'The country round about Lake Eyre has been opened up for many years, and the railway, north to Oodnadatta, now runs across the old hunting grounds of the Urabunna, whose numbers have dwindled very considerably [...] Nowadays the remnants of the Urabunna tribe are gathered together at the few outlying cattle stations [...]. They have long since, except in very small way, given up the performance of their old ceremonies [...] and only the older men know anything about, or indeed take any interest in, matters of tribal lore' (Spencer and Gillen 1912:17-18). Such a difference in the mode and speed of dispossession was largely due to the land itself; the spread and character of the crucial resource - water.

In the mound spring country ephemeral water sources and marginal springs were unable to sustain even the smallest human population on a permanent basis. The implications of this sudden collapse of the local population is that the entire spring network was crucial for the permanent occupation and no alternative was available (Hercus and Sutton 1985:2 and 14). This mode of dependency on springs suggests that they must have been occupied intermittently and not one at a time in chronological succession (eg. one spring being exclusively occupied for one hundred years before people moved to another spring).

This is the basic framework of the environmental component. While the distribution of archaeological sites can be predicted within this environmental framework (Hughes and Lampert 1985), such a prediction is less important in this study. Here, the distribution and characteristics of archaeological sites constitute a second component of the occupation model which largely shifts from predicting the settlement system to inferences about the behavioural pattern of a social system.

The main feature of an archaeological component is the dichotomy between major habitation sites located near the springs and other campsites located away from the springs. The spring sites are infrequent, large clusters of immense amounts of stone artefacts, bound only to the permanent water sources in the area. Non-spring campsites, on the other hand, are numerous but small with fewer artefacts, and are scattered all over the area. Although the kinds of implements found within the sites provide some clues to the nature and duration of occupation (eg. grinding stones, chapter III), the sheer amounts of archaeological material suggest that spring sites were occupied longer and many more times in comparison to non-spring sites which were incidental encampments of only a short duration.

Some sites of intermediate character, such as a relatively rich campsite near a rock-hole but away from the springs, or a very poor mound spring site (eg. Morris Creek site C and Davonport site D respectively), play little part in the model. However, examples of these rare sites are included in this study to temper the strong contrast between spring and non-spring campsites and to provide a more realistic picture of archaeological evidence. Also, they help to define what is characteristic about the majority of mound spring campsites - the unusual density of archaeological materials (Fig. 5, p.54).

Although it is possible to elaborate on several aspects of the environmental component and to increase the settlement data-matrix by intensive archaeological surveys, the basic geographical picture should not be substantially modified. Further insight into the behaviour of the past population can be attained through the study of a much finer matrix - the artefactual content of the campsites (chapters VII and VIII).

These specifics of climate and the settlement system can be broadly explained within an optimal foraging theory (Binford 1983; Smith 1983; Kelly 1983; Foley 1985) which proposes a set of risk-management strategies (eg. Minnis 1985; Halstead and O'Shea 1989). One of these strategies, clearly manifested in archaeological records, is mobility itself. This model of occupation focuses on scheduling the mobility within the region and the settlement system.

3. Geographical model

In contrast to static archaeological evidence, the model describes the dynamics and aspects of organization of population and its subsistence system. To emphasise this dynamic aspect, the past population can be portrayed in four different stages of cyclical transformations. These stages are related to geographical space and fluctuations of climate and biological resources.

1. Period of rains and rejuvenation of bio-resources: people in small highly mobile groups exploit the back country where widely spread ephemeral sources of water can be found. There is

a tendency to subsist on the foodstuff that is easy to obtain with high returns for low time/energy investment.

2. Early phase of dry period when bio-resources are still in supply, but surface water is becoming rare: people tend to exploit a variety of food resources closer to or around the springs. Several larger rock-holes can be occupied. It is the time when large numbers of people can congregate near the spring or rock-hole.

3. Main dry phase when surface water is not available and bio-resources are becoming increasingly scarce: people in smaller groups need to shift camps more often (from spring to spring) and tend to exploit even food of low return for high time/energy investment, such as seeds. The shrinking population of large game, like emu and kangaroo, seek constant access to water sources and hunting near the springs may become an increasingly crucial part of subsistence strategy.

4. Early rain-period when bio-resources are depleted most severely near the springs due to intensive exploitation by people. Surface water is becoming widely available: and depending on the intensity and frequency of precipitation, people tend to venture on longer forays to the back country away from the springs. High mobility is dictated by the scarcity of resources. If good conditions continue, the mobility may still be significant, but increasingly because of the search for different, high value, easy obtainable resources.

It must be remembered that factors such as duration of drought and rains, degree of depletion and regeneration of biomass, vary through time (chapter II). For example, the timing of rain in particular seasons is important for the re-establishment of mulga and the propagation of other plants that follow a seasonal life cycle. For other plants, such timing is less important. So, the sequence of wet and dry periods is superimposed in an irregular way on the cycle of seasons. These fluctuations of two independent factors (cold/hot and wet/dry) coincide at random, generating many permutations of environmental conditions as time goes by. For example, dry conditions can be cold or hot; July can be wet or dry.

These permutations of environmental conditions bear obvious consequences for human life. For instance, the winter drought may be less severe and the use of water for body-cooling can be significantly lower than in summer. Another example is the flooding of Lake Eyre, caused predominantly by rain in the distant north and north-east part of Australia. Although such floods usually coincide with an overall increase in precipitation, the lake can be filled with water during the locally dry period. In such circumstances fish, bird-eggs, and pelicans nesting on the lake shores may provide an exceptionally rich supply of food. This, in turn, can support a very large congregation of people for a short duration (depending on the supplies of fresh water). Oral tradition, however, suggests that Lake Eyre itself was rarely exploited (Hercus 1971:94), though such environmental factors cannot be easily structured in the model.

While fully aware of these unstructured factors, we can be confident that <u>the behavioural pattern of the local population is largely organised within the dichotomy between long dry periods (measured in months and years) and short wet episodes (measured in days and weeks)</u>. Furthermore, nuances in the dry/wet dichotomy, resulting from unstructured factors, can be largely translated to the low or high mobility and the short or long duration of camping in relation to the spring and non-spring locations. In archaeological records it can be simply represented by rich spring sites and poor non-spring sites. High mobility between spring sites results in short camping episodes, but they are difficult to detect in archaeological assemblages. Intensive mobility in the back country, away from the springs, is well reflected by the large amounts of small transient campsites.

For practical purposes, the model can be summarised in the following manner.

The dramatic depletion of food resources during dry periods exerted a strong pressure on the people to adopt a survival strategy binding them to the springs. Drought increased human dependency on the springs for water and intensified the necessity to forage more extensively to utilise dwindling resources. Under this pressure groups of people were forced to stay close to the springs while simultaneously moving frequently from one spring to another in search of food. In this model, the longer and more severe a drought, the shorter the camping episodes on each site. Therefore, more extensive group movement along the spring network should occur.

During the relatively wet periods the same force which drove people from spring to spring required them to forage laterally, away from the permanent sources of water (Strehlow 1947; Tindale 1972; Gould 1968). The pressure was to utilise resources spread over the large back country and also to allow for the regeneration of the area in the springs vicinity (ethnographic studies provide examples that in the arid areas people tend to save food resources near the most reliable waterholes for the harsher times, eg. Strehlow 1947; Latz and Griffin 1978:78; Cane 1984; Lee 1979).

4. Implications of the model

The geographical model of occupation relies on the climatic contrast between wet and dry, and the archaeological pattern of a settlement system. Allocation of campsites in relation to water sources provide the strongest expression of the life strategy. Although this model may not be the only way to integrate existing archaeological, historical and environmental evidence, its credibility is reinforced by three kinds of evidence:

1) Ethnography. Ethnographic accounts of comparable land use through cyclical dispersal of people in the back country and returns to reliable water sources in the areas of Cooper Creek - Coongie Lake (eg. Jones 1979b; Williams 1988; Veth et al. 1990), farther afield (eg. Meggitt 1962; Strehlow 1965; Peterson 1978; Cane 1984; Smith 1988), and in the other arid regions of the World (eg. Lee 1968);

2) Environmental factors. The mound spring country is harsh stony desert with very low bio-productivity, the least preferred

by Aboriginal people (Jones 1979b; Lucky Blackman pers. comm. 1990; Reuther 1981 provides supportive evidence from the Diari people). The mound springs are the only sources of drinking water and they are aligned in a narrow belt running across the country. Common sense suggests, and non-Aboriginal history of the area demonstrates, that the springs provide the only passage through the country and a lifeline for the local settlement;

3) Archaeological evidence. The allocation of archaeological sites in the area cannot be interpreted differently than that the mound springs were a focus of habitation while the back stony desert was exploited in ephemeral mode.

The model put forward here is to integrate existing evidence in order to develop and re-formulate the research problem, that is: what caused the variability of the mound spring campsites. Evidence produced so far suggests that variability is unlikely to result from a) chronology (that is: from cultural, technological or environmental changes through time because chronology itself cannot account for variation); b) various distinctive cultural groups controlling different springs in the same period of time; or, c) use of particular springs in different seasons.

One of the implications of the model is that if the same people were often moving from one spring campsite to another and performing the same activities at each campsite, all campsites should be quite similar. In other words, this postulates that people of the same cultural group would leave a similar behavioural imprint of their activities on all habitation sites in the uniform environmental setting. Such similarity should be further enhanced by the fact that there was frequent movement of people between the spring campsites.

It is assumed that given a uniform environmental condition people would behave similarly within culturally specific groups. In ethnography such culture-specific behaviour permits generalisations, for example, the Aranda people do things in different way than Pintubi: 'In many ways no stronger contrast can be imagined between two sets of Aboriginal cultural institutions than those of Western Desert folk and their eastern neighbours, the Aranda' (Strehlow 1965:132). In material culture it is reflected by the use of different resources and implements to achieve the similar goal of providing for human needs and sustaining the local population. This simple assumption, documented by various ethnographical studies, is one of the significant tools of archaeological practice. Grouping similar forms (eg. assemblages) permits scholars to make sense of the great variability in archaeological records through time and space (Childe 1964; Clarke 1978; also comment by Clark and Lindly 1991). (However it must be noted that archaeological groupings rarely if ever, correspond with linguistic or tribal entities observed in ethnographical context).

There are numerous examples of seasonal variation where people are engaged in the procurement of different food resources in a different part of the year and often in different season-specific locations (Thomson 1939). As a result, there is a significant variability between different season-specific sites and assemblages (eg. Cane 1984). To account for such seasonal transformation in prehistory it is necessary to establish a link between the different locations. Therefore, it is necessary to demonstrate that such variability is an imprint of a single, seasonally transformed society and not entirely different populations.

The current study, however, confronts quite a different problem. By all accounts the mound spring sites can be placed in a narrow chronological framework. The sites are linked not only by virtue of spatial proximity, but also by the fact that they were all established along a single network of springs. The mound spring sites form the spine of the regional settlement system. The region was habitable only because of the network of springs. The spring sites were occupied in an intermittent manner, and not one after another in chronological sequence, as there must have been frequent movement of people between the springs out of necessity. These factors suggest that one uniform mode of behaviour would characterise the camping activities associated with springs (in contrast to non-spring locations).

The variability of the mound spring sites is an example of ambiguity. On the one hand they represent the set of 'artefact-type categories which consistently recur together in assemblages' (Clarke 1978:490), on the other they display significant difference.

This conflict between expectations and evidence is another way of expressing the research problem in this thesis. The question arises how can this problem now be resolved ?

It seems obvious that model testing (if it was possible) is unlikely to offer a solution. However, it can help in developing a frame of reference. Transformations of subsistence strategy between dry and wet episodes represent an aspect of organisation. Although a social system operates within the organisational pattern, its existence is made up of human activities. So, the model can be seen as an attempt to outline the organisation of a social system in a specific environmental context, but it says very little about what activities people were performing within this framework. This can be addressed by archaeological evidence which is the foremost product of human activities. The analysis of archaeological material (samples) from different mound spring sites should lead to understanding the nature and some causes of inter-site variability.

In this context my thesis can be re-formulated as follows. The variability between the mound spring campsites results from similar work being done in different ways to maximise the use of local resources such as water, food, organic materials and stone for crafts and implements. Careful scheduling of activities within geographical space (and between different campsites) can be seen as the management strategy.

My thesis can be appraised by examining two more specific propositions:

1) Each assemblage appears significantly different despite the mound spring campsites representing superimposed discards from thousands of camping episodes. This would suggest that the range and proportion of jobs performed in the site was primarily influenced by the location of site and not by size, composition and affiliation of human groups that occupied the site in

different times;

2) Assumed tendency to maximise use of locally available resources, should be visible, at least, through use of lithic raw materials. However different proportion of tools in assemblages should not be exclusively determined by the local supply of stone material. If these assumptions are verified this would indicate a degree of planning, visible through acquisition of certain materials and tools that are unlikely to be obtained locally near the site selected for camping.

This examination requires specific archaeological data. In the next chapter I will describe the sites included in this study and the way in which the archaeological records et each campsite were sampled.

CHAPTER V

THE MOUND SPRING CAMPSITES: LANDFORMS, DITRIBUTION OF ARTEFACTS, POST-DEPOSITIONAL PROCESSES, AND ARCHAEOLOGICAL SAMPLING.

1. Introduction

The aim of this chapter is to provide evidence that will be used to demonstrate the inter-site variation and intra-site uniformity. Therefore provision of such evidence must be focused on two following propositions (compare chapter I).

1. inter-site variation is defined only by variable relative frequencies in a) lithic raw materials; b) size of stone artefacts, and; c) stone tool categories.

2. intra-site uniformity is defined only by even spacial distribution in relative frequencies in a) lithic raw materials; b) size of stone artefacts, and; c) stone tool categories, within the site area which preserve significant component of behavioural pattern (in contrast to site periphery with high component of natural or geomorphic configuration of artefactual materials).

In this chapter I describe archaoeological campsites, and sampling procedures. In the site descriptions I emphasise virtual exposure of archaeological materials and its consequences for sampling strategy. The observable site characteristics such as layout, distribution of artefacts, and post-depositional processes help to discriminate between the natural (eg. geomorphic) and the humanly-made pattern of the archaeological materials. Consequently a sampling strategy can be immediately focused on the behavioural component rather than probing blindly into unspecified manifestation of archaeological evidence.

The descriptive evidence and resulting sampling procedures are divided into four sections

- Description of the mound spring campsites;
- Post-depositional processes and behavioural patterns;
- Pilot sampling: an exploration of inter-site variation and intra-site uniformity;
- Sampling procedures.

An archaeological site is defined here as the area of a high density scatter of stone artefacts. They may be buried in the soil, be present on the surface, or display combination of surface and stratified deposits (Dunnell and Dancey 1983). High density is a relative category, but can be measured against a background scatter. The background scatter measured within the springs vicinity is less than 0.01% of the site density. With site density commonly exceeding 100 artefacts per $1m^2$, the background scatter represents no more than 1 artefact per $10m^2$. metre square. Often there is a sharp drop in density providing a clear delineation of the site boundary. In many cases this clear boundary is enhanced by the confines of the landform occupied by the site. In a few cases the boundary is less clear, but this is evidence of a fluvial disturbance or slope erosion (eg. Wangianna site H and Old Woman site G). Furthermore, the core area of the site is usually marked by numerous debris of fireplaces. Because such structures are not moveable, they indicate that the archaeological material is largely in a primary depositional position.

Often there are several sites near the one spring (eg. 6 at Welcome Springs; 3 at Old Woman Springs; Fig. 7, p.106 and Fig 15, p.115). Sometimes, depending on the distribution of landforms and associated archaeological material, these sites can be grouped together (Hughes and Lampert 1985). In this study every dense and clearly separated cluster of artefacts was defined as an individual site. On this account I recognise 27 mound spring campsites in the study area against 24 recorded by Hughes and Lampert (1985).

In this research, three small sites were included (sites A, B and G). Because of this the statistics of the sites differ from the quantified data provided by Hughes and Lampert (1985), see Table 4, p.103).

There are some characteristics of the camping localities and their immediate surroundings that are not quantified in this study. However, these traits are expected to influence the nature of the archaeological deposits. Some of these characteristics can

Table 4: comparison between the archaeological mound spring sites recorded by Hughes and Lampert (1985) and the sites selected for this study

	MEAN SITE AREA 1m^2	ARTEFACT DENSITY per 1m^2	ESTIMATED NUMBER OF ARTEFACTS per site	N
Hughes and Lampert 1985	20,573.9	100	2,620,840	24
range:	(375-250,000)	(25.5-300)	(10,000-3,000,000)	
this study	17,871	179	3,205,714	7
range:	(1,500-30,000)	(33-833)	(240,000-6,700,000)	

be directly related to the artefacts on the site. For example, an outcrop of stone material in the site vicinity would be notably reflected by the types of raw material present on the site. Site C is a good example of this situation. Here, silcrete from the nearby outcrop is the dominant type of stone in the assemblage. Another example is a site far away from any kind of stone suitable for flaking. In this case, it is likely that most material transported from far away would be intensively reduced. Site ST illustrates such a situation and here all artefacts are, on average, the smallest among the camps. Other characteristics of the landscape, such as the nardoo swamp or small sand-ridges favoured by emus for nesting, can not be linked to the archaeological deposit in a reliable way, though they seem to be reflected in the site content. Such characteristics can be used as circumstantial evidence in an attempt to explain the functional variation among the campsites.

Another characteristic aspect of the sites is the ongoing disturbance caused by natural forces. An understanding of this factor is especially important in developing a sampling method and in the interpretation of a site. Some symptoms of the natural destruction of the site are clearly visible in the current landscape. Although these symptoms were not measured in a systematic manner due to time constraints, some observations and measurements were obtained. They demonstrate selected aspects of the site dynamics and contribute to an understanding the sites' formation process. They also help to establish the temporal framework of occupation.

2. Description of the mound spring campsites.

The mound springs are distributed within the narrow strip bending around southern and western fringes of Lake Eyre. Most of the springs are within five kilometres of the Oodnadatta Track. This track may be viewed as a transect running across the landscape in the springs vicinity. The seven campsites selected for this study are associated with several different springs encountered on the way from Marree to William Creek. They are, two campsites at Welcome Springs (26km from Marree), one campsite at Wangianna Springs (35km), two campsites at Davenport Springs (48km), one campsite at Old Woman Springs (61km) and one at Strangways Springs (145km). In addition, one campsite associated with a rock-hole at Morris Creek was included in this research. It is about 15km north of Davenport Springs and 18km north-east of Old Woman Springs (Fig. 4, p.30).

WELCOME SPRINGS

Welcome Springs ($29^0$40' S; $137^0$49' E) is located within Welcome Creek valley about 5km south of the Oodnadatta Track (Fig. 6, p.105). The creek is entrenched here to about 10 metres below the gibber plain with steep eroding slopes. Several mound springs are located in this section of the creek (Photo 3). All active springs are in the middle of the valley. This section of the creek is like a basin about 1 km long and 0.7 km wide, partially enclosed by the gibber plateaux. A relatively narrow gap provides drainage into a much broader and lower flood-plain further north (Hughes and Lampert 1985; Florek 1989b).

In the middle of the creek valley there is a local, but extensive, travertine profile which developed probably when the springs of a former generation were discharging enough water to form extensive shallow pools. The travertine sediments delineate the former bottom of Welcome Creek which at that time must have been narrower. The travertine development was interrupted by the substantial reduction of water discharge and a further dissection of Welcome Creek.

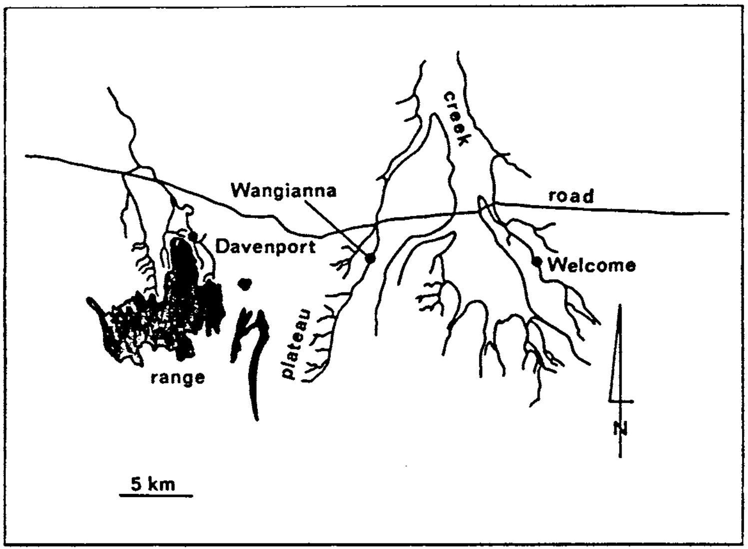

Figure 6. Location of Welcome Springs, Wangianna Springs, and Davenport Springs.

The elevation of the valley floor and the slope gradient of the eroding gibber plain suggests that after the travertine profile was formed some important changes took place in the basin. The creek dissected a new waterway along the left bank, which subsequently was filled with sand and silt from the slopes. The newest waterway then developed along the right bank where the slopes are steeper and the channel bed is about 3 m below the travertine profile. The steep bank and the travertine plate (occupied by site B) are currently undercut by the dissecting creek. In addition, the soft sediments from below the travertine crust are slowly washed out and in some places, the plate is visibly sinking into the soft clastic substratum (Photo 7).

On the plateaux above the creek a variety of stone can be found. All four types of stone commonly used in this area are present, however none is of a good quality for flaking. They are small weathered pebbles of quartzite, quartz, silcrete and occasionally chert. Along the edges of the plateaux a thick crust of the conglomerate below a gibber surface is exposed. As the erosion of the slope progresses the conglomerate breakes into small and larg blocks. Smaller chunks of conglomerate were brought into the camps and used as cooking stones and anvils. Some quartz pebbles were also extracted from the conglomerate for knapping.

On the lower slopes of the plateaux, where large pockets of sand are formed and there is some shelter from the wind, several tall shrubs can be found. Similar small groves of shrubs are in the crevices on the plateaux along the creek. On the open flat only some isolated and usually small shrubs are present. It is possible that the overall distribution of these shrubs has not changed much since pre-contact period. However, Welcome Springs is a watering point for the sheep on the Callanna Station. Low shrubs, such as salt and bluebush, and grasses have probably been drastically reduced over the last 100 years with intensive grazing.

About 1 km north of Welcome Springs the creek enters a low flat area where, after heavy rains, a large swamp of stagnant water is formed. The wet phase of the swamp is followed by the lush growth of grass and this flat must have been a potential source of seeds.

At each of the valley sides at least two large scatters of stone artefacts can be found. Another scatter is located on the travertine plate in the valley floor, and it is designated here as site B (Fig. 7, p.106).

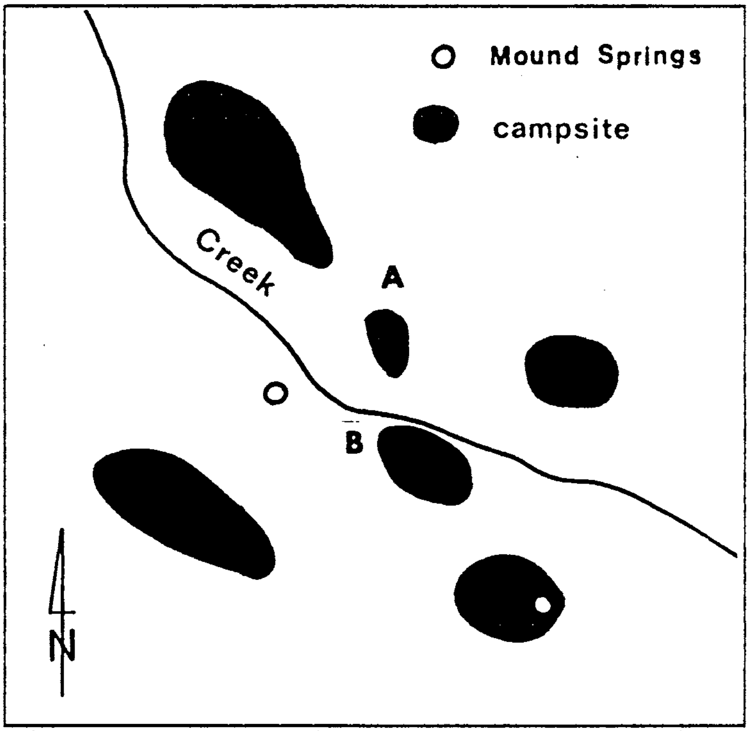

Figure 7. Location of archaeological campsites at Welcome Springs (not to scale; area: 1 km x 0.7 km approximately).

Site A (Fig. 8, p.107)

Site A is located on the slope of the north-eastern bank of Welcome Creek. The site occupies a narrow tapering ridge, protruding from the edge of the eroding slopes of a gibber plain, about 10 m above the creek. Flanked on both sides by small deep-cut gullies (Photo 8), partially filled with drifting sand, the ridge extends towards the creek bed for about 100m. This ridge is wider (c. 40 m) and steeper in the upper northern part, and flatter in the middle, with its edges sloping sharply down. The southern end touches the recent waterway. The ridge consists of a shallow shale overlaying sandy gravel and a rocky core of unknown character, but rich with calcium carbonate. The total site area is about 1500 m2 with about 240,000 stone artefacts. The site surface is covered with a scatter of both artefacts and other non-artefact stones. The non-artefact stones have originated from the gibber plain above the site and from the conglomerate beneath the gibber. They were re-deposited in the erosion process of the gibber plain. In terms of volume, the most common material is quartzite derived at least partially from the eroding slopes; portions of it were clearly brought to the site by people. Quartz pebbles and flakes are the most numerous on the site. They may have been collected on the gibber, but larger and better pebbles of quartz can be extracted from the local conglomerate and it seems that such extraction took place on the site. Other local material, rarely used for flaking, is represented by indurated sandstone, shale and mudstone. Chert, when available locally, can be found in the

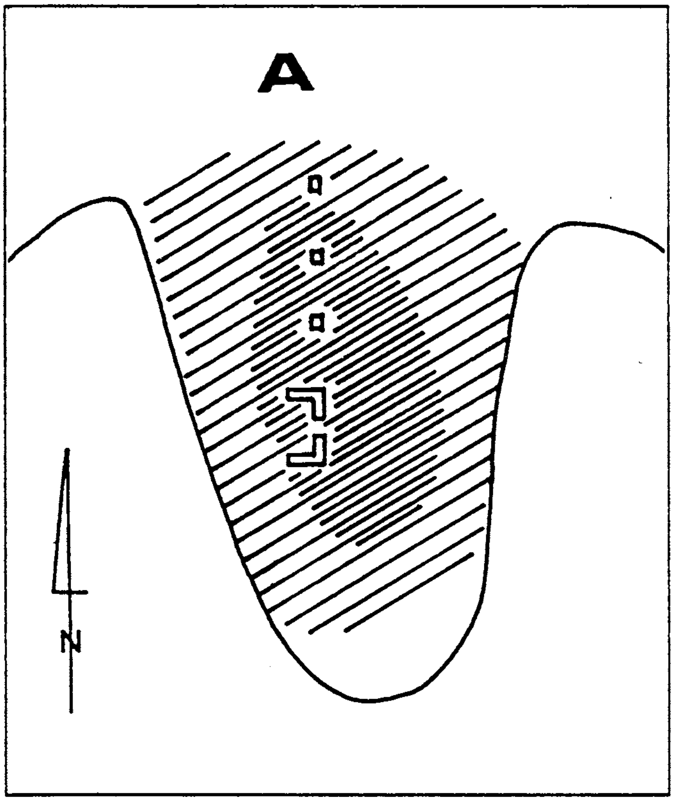

Figure 8. Outline of site A Welcome Springs with sampling areas.

form of small weathered pebbles. Therefore, it is likely that most of the chert present on the site was carried in from other unknown sources. Silcrete can also be found locally, but better quality nodules for flaking were brought from elsewhere.

Site A contains a relatively large number of medium to large-size stone artefacts, the latter are generally quartzite. There is some evidence of crude flaking on the site.

Site B (Fig. 9, p.108)

Site B occupies a part of the travertine plate (about half a metre thick) elevated to about 3 m above the creek bed. The site covers approximately 5,600 1m^2 with an estimated 1.5 million stone artefacts.

Site B is almost perfectly flat with a vertical variation contained within 70cm over the large area (80 x 70 m). Horizontal displacement of artefacts is more restricted here than on the slope, though such displacement is still evident at the steep edges of the north and east boundaries of the site where the plate is undercut by the creek. It is apparent that every site consists of a core area defined archaeologically by the high density scatter of artefacts, and a peripheral area with scarcely distributed objects.

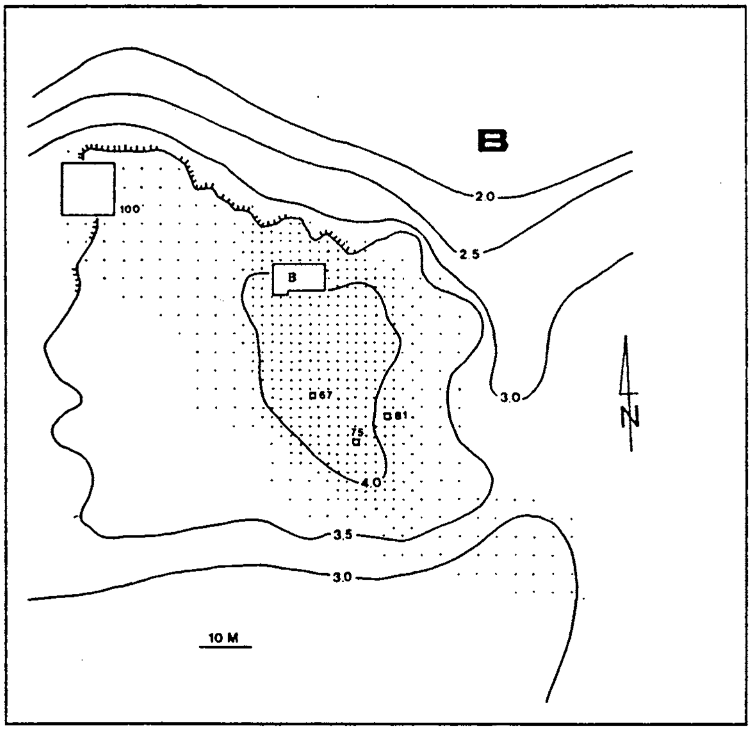

Figure 9. Layout of site B with elevation related to the creek bed (in metres) and location of sampling areas (B, 100, 67, 76, and 81). Dense dots represent high density area; sparse dots - site periphery.

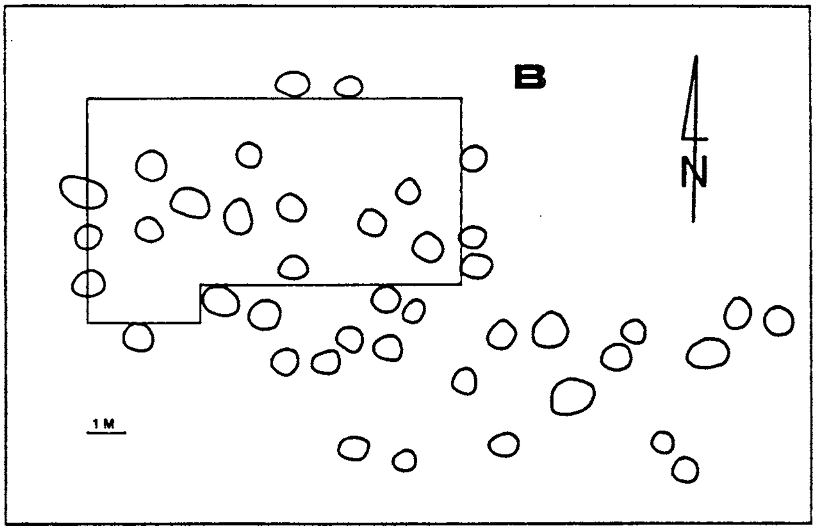

Figure 10. Site B: sampling area (boxed) with remnants of fireolaces plotted within and in adjacent zone.

Due to its flat position and perfect visibility, site B demonstrates this feature clearly. Stone artefacts are distributed evenly over the site with the only density difference occuring between the core area and the periphery. Apart from the numerous grinding stones and their fragments, most artefacts are small. There is much debris from fireplaces in the high density area, on average one fireplace on each 3.5 1m^2 (Fig. 10).

WANGIANNA SPRINGS

Wangianna Springs (29^{0}40’ S; 137^{0}42’ E) is located within Wangianna Creek, 2 km south of the Oodnadatta Track (Fig. 6, p.105). Wangianna Springs is at the fringe of an extensively undulating landscape. This is reflected in the relief of Wangianna Creek itself. Its west bank is high, in places very steep, with narrow deep erosional gullies. The eastern bank is gently undulating and flattish. Wangianna Springs is on the flat, wide bottom of the creek valley. About 200 m north of the springs itself, the creek enters a narrow channel flanked by the steep high bank on one side and by the low flat area along the other bank. On this small flood-plain an extensive scatter of stone artefacts marks the Wangianna campsite H (Hughes and Lampert 1985; Florek 1989b).

Eroding gibber slopes provide a variety of stone. Among them are some larger chunks of quartzite which were flaked within several hundred metres of the site and are documented by isolated knapping floors (Photo 9).

Along the creek a low to medium density shrub cover is present, although it was possibly denser in the past before sheep and rabbits made their impact on local vegetation. Within the camp area several patches of tall shrub are found; previously they may have been more wide-spread, providing natural shelter and an ample supply of firewood and raw material for woodcraft.

A diverse relief provides suitable conditions for a variety of plants and animals within several hundred metres of the campsite. For example, several patches of nardoo can be found down the creek. Throughout the 1980's several examples of emu nesting have been observed here. There is a sizeable population of shingle-back lizards in the area and flocks of parrots can often be seen near the spring.

The Wangianna Spring water is not potable at present, therefore grazing in the spring vicinity has recently become unattractive.

Site H (Fig. 11, p.111)

The site H is located on the small flood-plain along the east bank of the creek. It covers an area of about 30,000 m^2 with about 5 million stone artefacts. They are small, with chert comprising a relatively large portion of the assemblage.

These artefacts tend to concentrate within small clusters, 2-3 m across (Fig. 12, p.112) which must be attributed to the occasional flooding of the site (see chapter VI). The disturbance of the site, caused by floodings, is corroborated by the fact that there is no clear site boundary down the creek and the artefacts are spread over a large area, gradually decreasing in density. The density of large to medium size objects decreases even more sharply. Older fireplaces are nearly totally buried in the soft soil and the youngest are covered with a thin crust of silt. It appears that archaeological deposit has been redistributed within the site area.

DAVENPORT SPRINGS

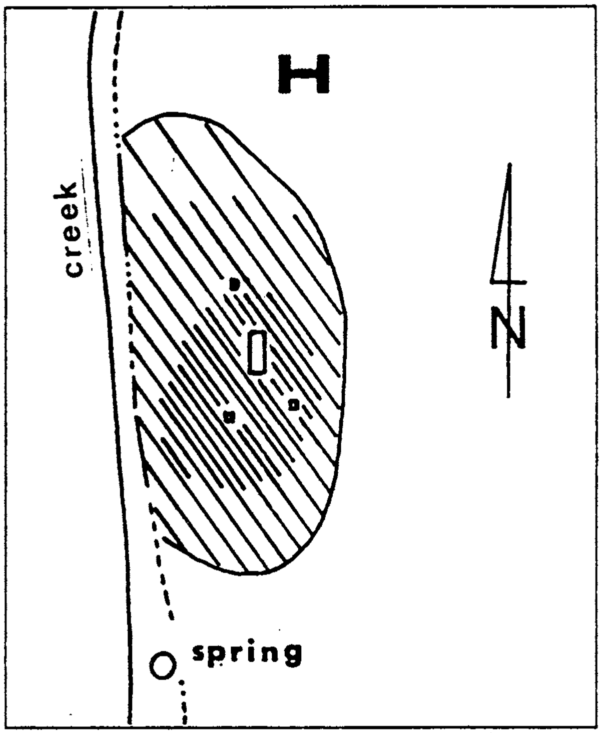

Figure 11. Layout of site H (Wangianna Springs) with location of sampling areas.

Davenport Springs ($29^0 39'$ S; $137^0 35'$ E) is about 3 km south of the Oodnadatta Track within the large valley cut through by Davenport Creek (Fig. 6, p.105). The valley is at the north margin of a small range. The irregular shape of the valley can be attributed to two different kinds of sediments, rocky sandstone and soft clastic deposits such as silt, mudstone and sandy gravel. Because the sandstone is eroding slower than other clastic sediments, the valley is excavated in an irregular way. Within the creek valley several flat-top hills of sandstone are present. Mound springs are scattered within the area of about 0.5 km^2 on the valley floor, but above the current waterway. The recent waterway under cuts a soft, clastic deposit of the undulating gibber along the right bank.

In places, up to 5 m of the mudstone profile with gypsum laminae are exposed by the dissecting creek. This deep dissection is related to the youngest change in the waterway. During the local rain (I observed such an incident in December 1986), the nearby range is responsible for supplying a large volume of water and a high initial velocity. However, this section of the creek is poorly drained and further north, the creek gradient is extremely low. After an initial rapid flow, the creek slows down and the extensive pools of water can remain up to several weeks after rain, although this water is saturated with salt.

In this section of the valley, the south-west side is rocky with large parts of sandstone sediments being exposed; the north-east side is marked by the slopes of eroding gibber. While the rocky side is almost completely barren, the lower terrace of the gibber side contains some patches of tall shrubs.

There are two campsites at the Davenport Springs. One of them, site D is located on the north-east terrace and is close to the most extensive patch of shrubs in the area. The other, site E is located on a flat hill-top within the creek valley. The hill, standing about 10 m above the valley floor, has a couple of mound springs at its foot. While the hill provides a very good observation point over the whole area, there is no natural shelter from the wind or mid-day sun.

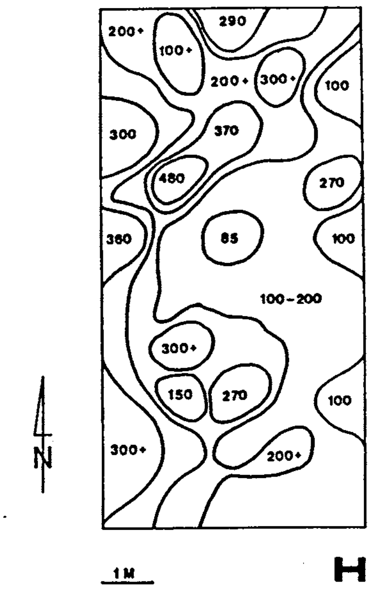

Figure 12. Site H: sampling area (boxed) with density of artefacts plotted within it.

The floors of both camps are covered with gibber pebbles, but no good quality material for flaking exists. The gibber plain and especially its eroding slopes must have been the closest source of suitable stone material. Flakes, cores and stone tools can be found on the gibber along this section of the creek. Also, there are some isolated knapping floors where large blocks of quartzite have been reduced and only some pieces carried away, presumably to the camp (Photo 10). Large pebbles of quartzite and other material can be found on the eroding slopes of the gibber. These pebbles appear to be a better quality material for flaking. Some large quartzite pebbles or their fragments are present on both campsites. So, stone material was available in the vicinity but was not well localised and the procurement of suitable stone required some fossicking.

Site D (Fig. 13, p.113)

Site D is located on the narrow creek terrace covering an area of about 30,000 m^2 with about 1 million stone artefacts. This terrace stretching along the current waterway is within the creek bend and is undercut by water. Steep slopes of the terrace are 3-6 m above the creek. The speed of the erosion is difficult to assess, but some fencing posts erected on the terrace edge less than a hundred years ago have fallen down as the result of continuing destruction. Behind the terrace is a little rivulet, parallel to the creek, which borders the site area along the gibber plain. One end of the terrace gradually slopes down to form a small flood-plain flanked by 10-15 m high slopes of the gibber plain; the other end is truncated by the creek.

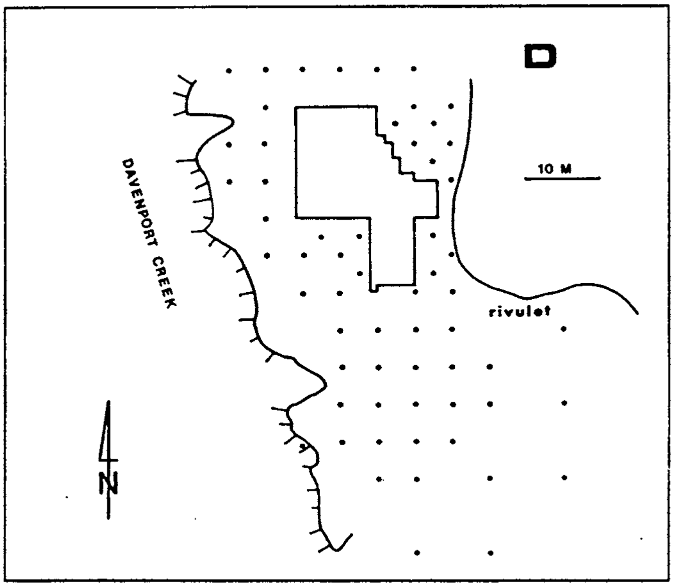

Figure 13. Layout of site D (Davenport Springs) with location of sampling areas in relation to the extent of archaeological surface scatter.

All mound springs are located on the other side of the current waterway of Davenport Creek, 100-200 m away from the site D. These springs are easily visible from the site.

Site E (Fig. 14, p.114)

Site E is located on the small mesa covering an area of 22,000 m^2 with about 6.7 million stone artefacts. The mesa is built of several layers of sandstone, differing in texture and colour. In the sandstone deposit some lenses of ochre are present. There is great variation in ochre colour, with many shades of red, yellow, purple and orange. The mesa is covered with a very thin layer of soil (2-5 cm) and residual material of a gibber - forming a dense cover of small quartzite and silcrete pebbles. Two small springs are at the foot of the mesa; other springs are 100-200 m away and can all be seen from the site.

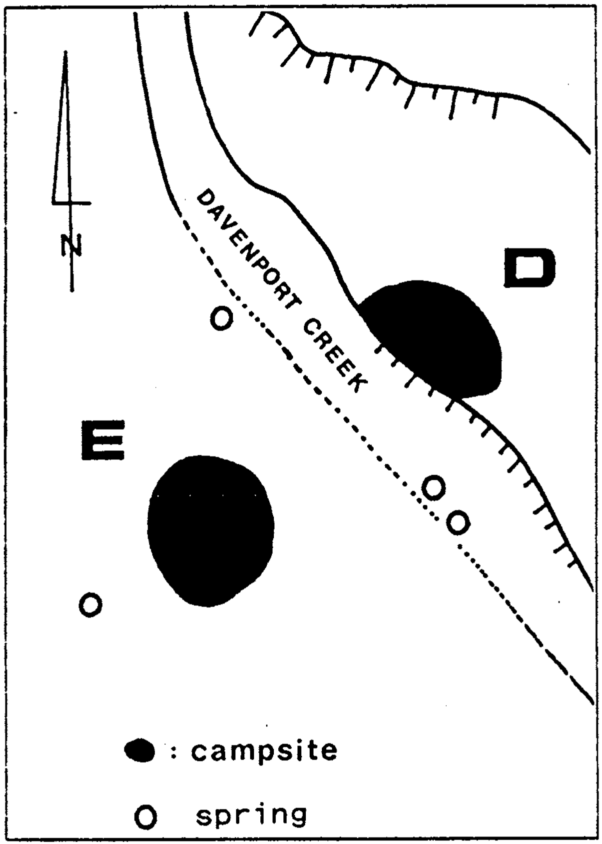

Figure 14. Location of sites D and E, Davenport Springs.

OLD WOMAN SPRINGS

Old Woman Springs (29°36’ S; 137°27’ E) is about 2 km north of the Oodnadatta Track (Fig. 15, p.115) at the east margin of Hermit Hill - the tallest hill in the region (121 m). In this area Finniss Creek marks a clear boundary between the gibber plain to the east and the large body of Hermit Hill to the west. The hillside bank is built of Proterozoic rocks covered with a thin layer of younger sediments and several local outcrops (Thomson and Barnett 1985). The gibber bank is formed of clastic sediments and a steep eroding slope of the undulating plain.

A range of stone types can be found on the gibber, as well as on its eroding slope. However, better localised and superior quality material can be found within the outcrops on the hillside bank. Here, quartzite and yellow ochre have been extracted from well localised sources (Florek 1989c).

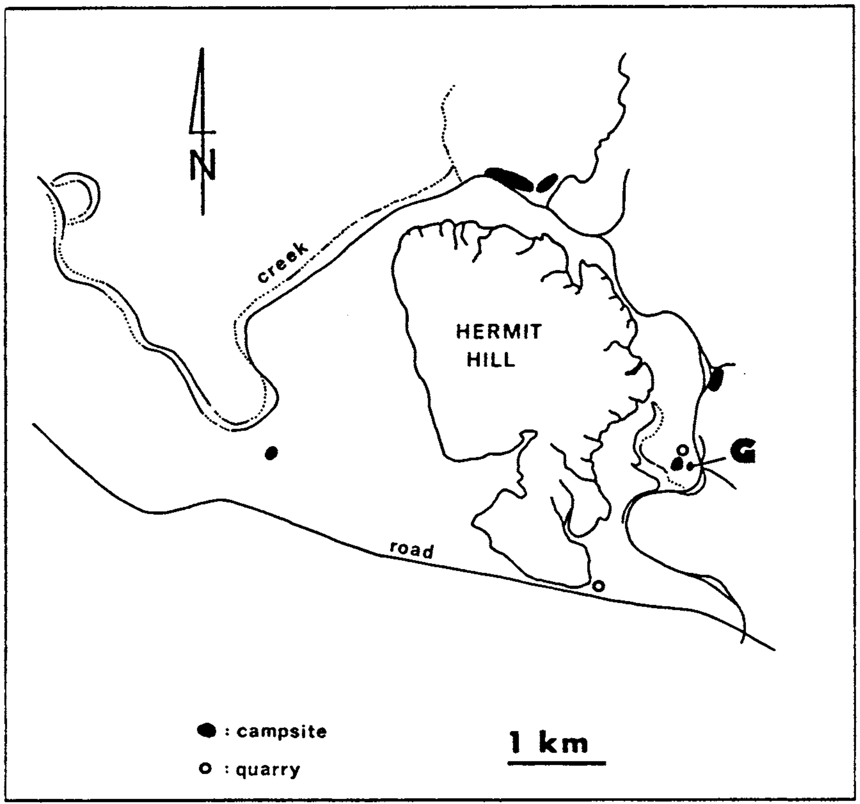

Figure 15. Location of site G (Old Woman Springs) in the vicinity of Hermit Hill. Other campsites (black) and quarry sites (white) are marked on the map.

In this area several extensive groves of shrubs are present. Among them is the largest tall shrub-land in the whole region. In terms of the availability of water, wood, and a variety of plants and animals, the Hermit Hill area appears to be the richest niche in the region, able to accommodate relatively large numbers of people simultaneously. This conclusion can be supported by the half dozen campsites, some stone quarries and several ceremonial sites recorded within the area (Potezny 1978; Hughes and Lampert 1985; Florek 1989b, 1989c).

About forty mound springs are present around Hermit Hill. However, only a few of these springs are currently active. One of the Old Woman Springs is situated within Finniss Creek, just above the current waterway about 130 m west of the gibber plain. The mound of this spring is capped by a small isolated dune. This dune has developed in the "recent past" which coincided in time with human occupation.

Site G (Fig. 16)

Site G is located on a small sand dune (Photo 4) covering an area of about 6,000 m^2 with about 5 million stone artefacts. A substantial portion of the archaeological material is buried in the sand to a depth of about 1 m below the recent surface. The density of stone artefacts on the surface is up to 1000 objects per 1m^2. There is evidence of extensive flaking taking place within the site. In addition, there are about 280 small fragments of macropod bones and 10-15 pieces of ochre per 1m^2. The remnants of an estimated 25 fireplaces are present within every 100 m^2 on the surface.

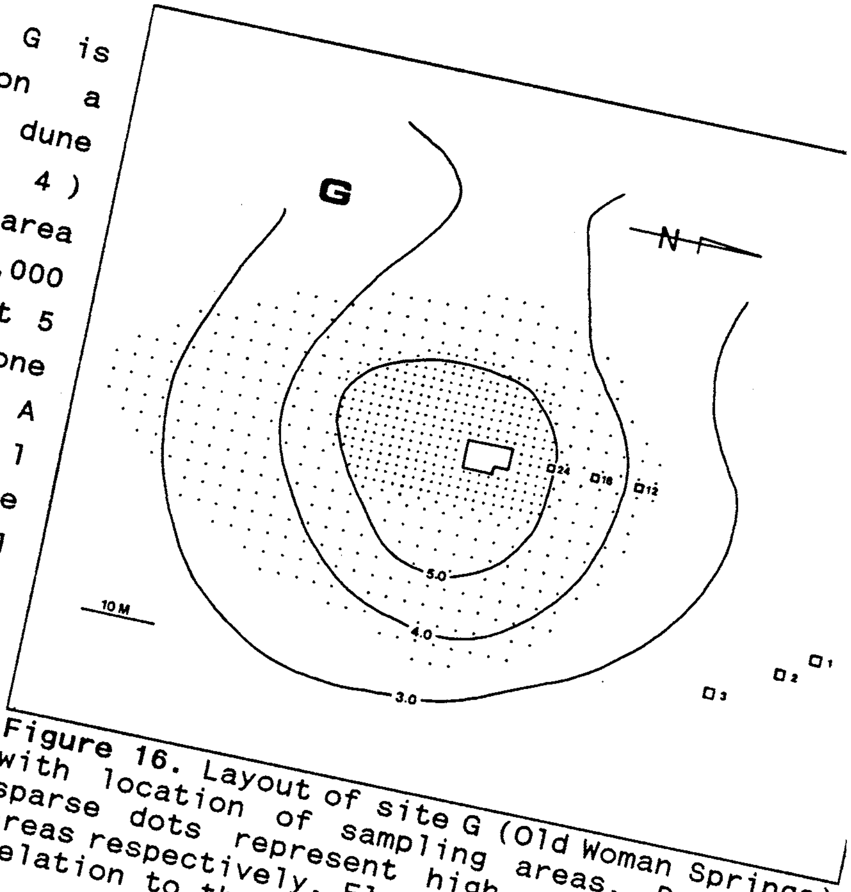

Figure 16. Layout of site G (Old Woman Springs) with location of sampling areas. Dense and sparse dots represent high and low density areas respectively. Elevation (in metres) is in relation to the creek bed.

The dune is rapidly deflating (Photo 6) and the archaeological material is being moved down into the creek bed. I estimated that one quarter (c. 60-70 cm) of the dune has been deflated, probably in the last hundred years, due to vegetation removal caused by rabbits that spread in the area in the two final decades of last century (Wood 1984).

STRANGWAYS SPRINGS

Strangways Springs (29°05'S; 136°33' E) are about 1 km south of the Oodnadatta Track within the large bent of Warriner Creek (Fig. 17). Strangways Springs is a large cluster of many hundreds of mounds packed tightly into an area of about 0.5 km^2 with several springs scattered around. Some of these springs still discharge water which is currently used by cattle from Stuart Creek Station.

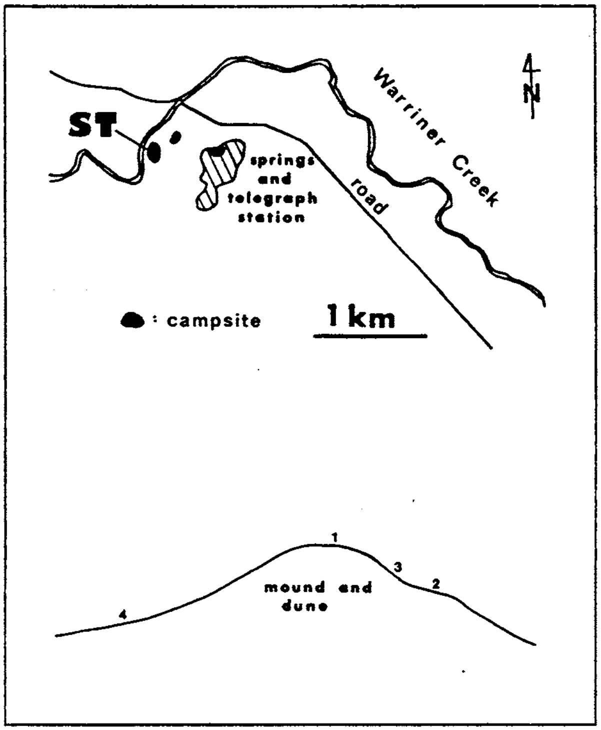

Figure 17. Location of site ST (Strangways Springs) and schematic cross-section of the dune (1: top; 2: flat-slope section; 3: upper-middle slope; 4: lower-middle slope).

The major cluster of springs forms an extensive hill covered with travertine. This cluster of mounds has developed when the springs were active, possibly discharging much more water than any active spring in this area today. Apparently, there is no source of stone other than travertine in the springs vicinity (Reginald Dodd, pers. comm 1988). The Overland Telegraph station established here last century was built from the local travertine. All flaked stone artefacts have been made of material brought from outside this area. On average, stone artefacts are smaller here than on other campsites included in this study (a similar situation is found at the Bubbler Springs).

In a broader context, on the south-east side of Warriner Creek, but much further from Strangways Springs, there is an extensive gibber plain while on the north-west side there are large areas of dune fields. Site ST is located on the south bank of Warriner Creek where the boundary between these two distinctive landscapes is very clear (Florek 1988a).

Site ST (Fig. 18)

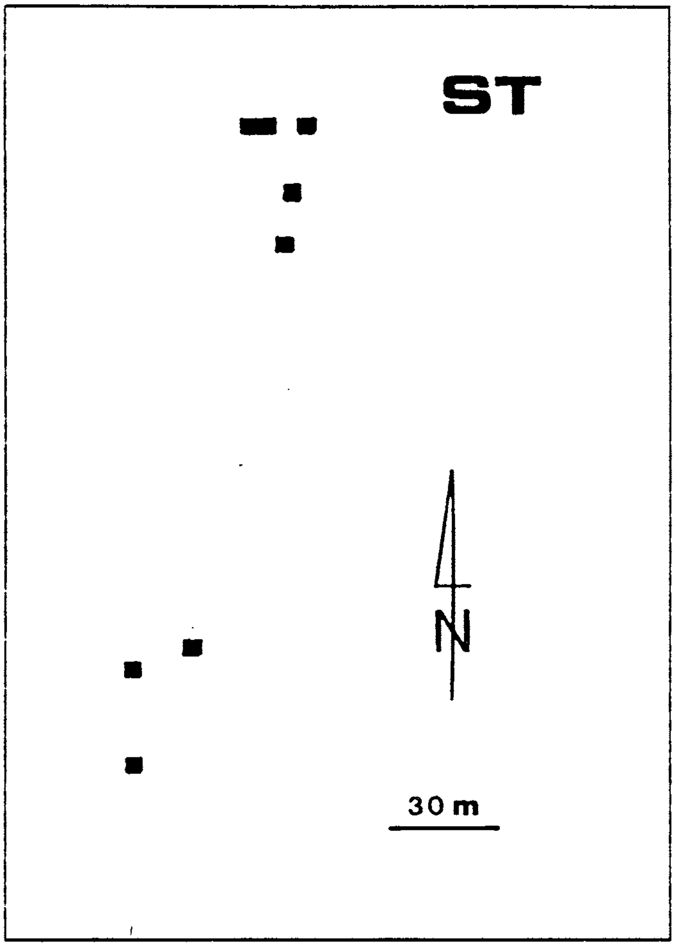

Figure 18. Layout of sampling areas on site ST, Strangway Springs.

Site ST is about 700 m west of the major cluster of springs separated by the low flood-plain. A dry mound of the spring is currently covered with a sand dune which extends about 700 m north-east towards the creek. The middle section of the dune is now eroded, partially due to the cattle track crossing it. Parts of the south slope of the dune are covered with a relatively thick shrub. At the northern end, a small grove of river red gum is present.

Site ST occupies a small section of a dune capping the non-active mound of the artesian spring. Its area is about 30,000 m^2 with about 3 million stone artefacts. Silcrete is the most common type of raw material on the site and most artefacts are very small. Several well-preserved fireplaces contain large amounts of calcrete used as cooking stones. There is evidence suggesting that these stones were moved from one fireplace to another.

THE MORRIS CREEK OUTCROP

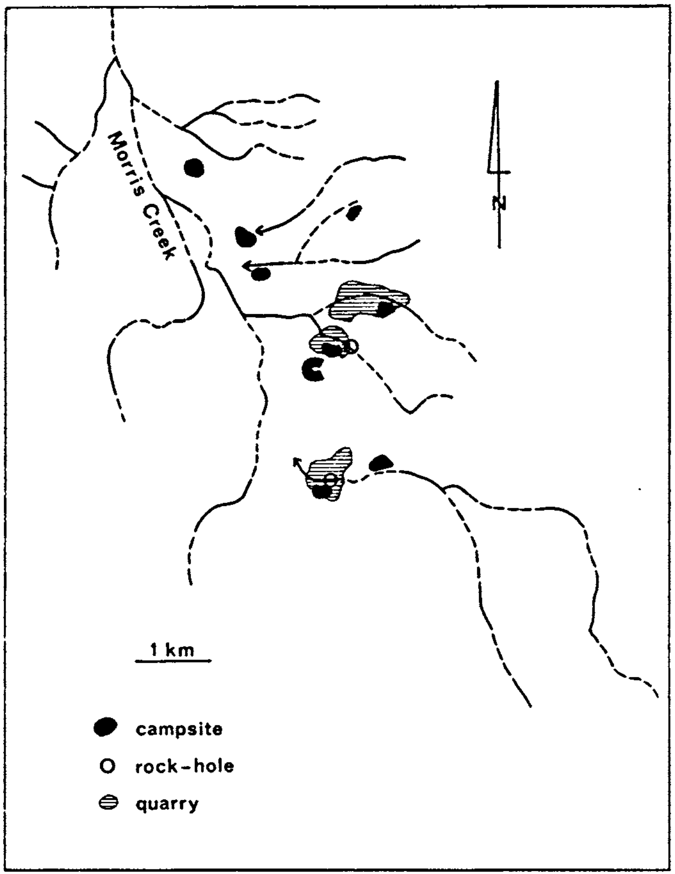

Figure 19. Upper section of Morris Creek with location of site C, other habitation sites, and silcrete quarries.

Morris Creek Outcrop ($29^{0}32'$ S; $137^{0}37'$ E) is about 12 km north of Oodnadatta Track and 15 km north of Davenport Springs (Fig. 4, p.30 and Fig. 19). It is located on the edge of the gibber plateaux overlooking the extensive valley of Morris Creek. The camp, designated here as site C, is near the small rock-hole and in the vicinity of a large silcrete outcrop with many distinctive workshops scattered over the landscape. While the gibber plain is almost completely barren, there are small groves of shrubs along the creeks and around the rock-hole. 2 km south of the site C there is another larger rock-hole with more water (Florek 1986, 1989b).

The area of the Morris Creek outcrop provides a plentiful supply of wood, and some shelter from wind, while sizeable patches of grass are found not far away. There is plenty of stone for knapping and in the nearby workshops large silcrete blades were produced. The location was attractive for camping, but during prolonged droughts, with local resources becoming quickly depleted and neither of the two rock-holes holding permanent water, it must have been only a temporary retreat.

It should be noted, however, that during the rainy period there is plenty of water in the claypans and the ephemeral billabongs spread widely over the landscape. Hundreds of transient camps can be found on the plains along Morris Creek. There are three possible factors accounting for the relatively dense archaeological deposit on campsite C. Firstly when surface water dries up all around, the Morris Creek rock-holes can provide temporary retreat. Secondly it provides much better shelter than the open landscape stretching for miles around the outcrop. Finally, there is a source of good quality raw material, exploited primarily for stone knife blades. Such blades are rarely if ever found on the campsites (similar observations were made in arid NSW, D. Witter pers. comm. 1991)

Site C (Fig. 20)

Site C is located on a gentle slope above a gully, near rock-hole, in the vicinity of the silcrete outcrop. It covers an area of about 1,500 m^2 with about 45,000 stone artefacts. Archaeological material is present only on the surface. There are some pockets where artefacts are superficially buried in drifting sand. The slope gradient increases towards the rockhole and it seems that archaeological deposit moves slowly down the slope.

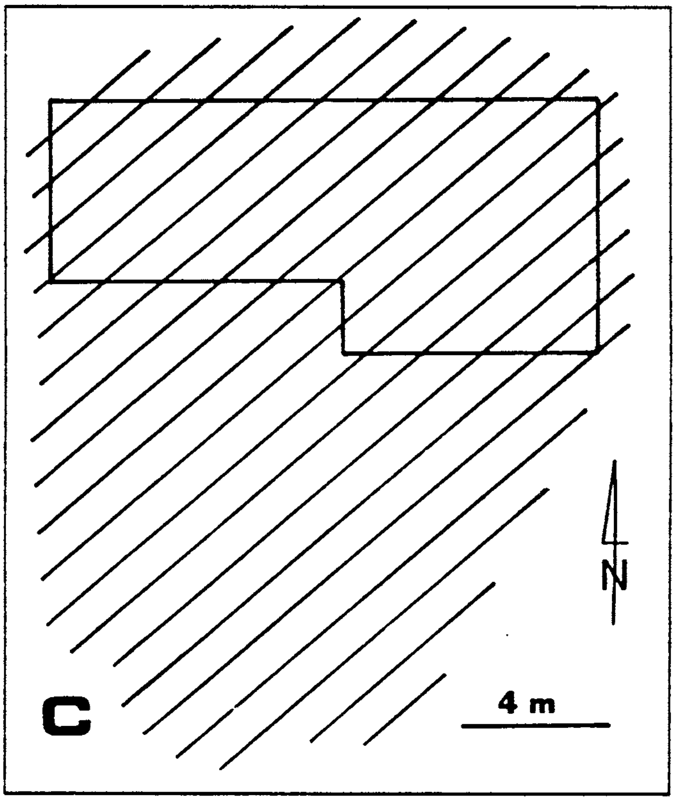

Figure 20. Inner part of site C with location of sampling area.

In summarising the site descriptions several points must be emphasised. The site area is usually clearly defined in the geographical space. The distribution and character of archaeological material attests that the sites are in their primary depositional position. Very rich, homogenous scatters of stone artefacts suggest that the sites resulted from many occupational episodes superimposed tightly one on the other. The core area of each site is characterised by a high density of artefacts enhancing its homogenous character. A drop in density at the site periphery is attributed to the different use of this marginal area. When the site periphery coincides with a slope, advanced displacement of deposits and its sorting force contributes to the drop in density. Both the different use and the erosional displacement makes the site periphery distorted in terms of quantity, proportions and spatial distribution of artefacts.

It must be noted that some of the mound spring campsites are far larger in area and with much lower density. One site in the area of Hermit Hill North is the best example. It stretches for about 800 m on the gentle slope of the longitudinal dune. There is considerable spatial variation over the site area, suggesting that almost every camping episode occupied its own unique space on the dune. Such an arrangement can be attributed to the shape and size of the dune itself and several springs present along its entire length. However, such a coincidence of numerous springs scattered over a large area, and spacious sandy landform for camping are rare in the mound spring country.

3. Post-depositional processes and behavioural patterns.

Over the last two decades there has been a growing awareness that surface archaeological deposits may be more than impoverished cousins of stratified sites. These sites are used more often for research projects in their own right, not only as a means to recognise sub-surface deposits in field surveys (Lewarch and O'Brien 1981; Fish and Kowalewski 1990).

Mound spring campsites are all identified as surface sites (Hughes and Lampert 1985). This is generally correct in the sense that these sites were never sealed by overlaying long-term stable sediments similar to the situation found in a cave or shelter. Stratified archaeological deposits are subject to different, usually more settled dynamics where the post-depositional history of artefacts is broadly parallel to the history of the parental stratum. Surface archaeological deposits, however, are in a different realm (Straus 1990).

Most of the mound spring sites are located on elevated landforms, such as sand dunes or creek banks. These elevated landforms themselves are the subject of erosion. The only natural sediments that may cover archaeological materials are a sandy coat on a dune or a thin layer of silt on a creek bank. Some sites on a dune are partially buried under the sand and subsequently exposed by deflation. Archaeological deposits along the creeks are destined to be washed into the creek by the gradual erosion of the banks or catastrophic destruction caused by flooding.

While this incidental sedimentation and erosion contribute to horizontal and vertical displacement of archaeological material, there is a constant factor of gravity which, supplemented by fluvial and aeolian forces, draws the artefacts to the lower slopes and creek channels. Because the site structure is made up of a distribution of objects and their spatial relationship, the force of gravity is effectively working towards a complete annihilation of the sites, although not necessarily a physical destruction of artefacts themselves. In theory, at the bottom there should be more stable conditions for sedimentation. However, at Lake Eyre the violent fluvial episodes keep excavating and dragging these bottom sediments further towards the extensive depression of Lake Eyre itself (this re-deposited material would be of very limited use for archaeology but the cost of recovery enormous).

Mound spring camps are located on the landforms where erosion is a predominant force, while deposition is incidental and highly unstable. The long-term trend is a complete re-deposition of archaeological material from the sites. These sites are "par excellence" surface sites which never were and never will be fully buried in their primary depositional location and spatial configuration. The rapid destruction of the mound spring sites provides conjectural evidence of their recent origin. This rapid destruction helps to explain why the older sites are so rare in this area and why the youngest occupation seems to appear suddenly without ancestral population.

The depositional history of these sites can be inferred from the distribution, density and total number of artefacts. Many, probably thousands of camping episodes followed each other in the short span of time. Each later episode was not only contributing a new portion of artefacts, but causing disturbance and blurring of former spatial patterns. Debris resulting from the earliest episodes is likely to be widely dispersed over the site area. Some debris were recycled; the heat retaining stones were probably removed several times from one fireplace to another. This process can be called occupational disturbance (Hughes and Lampert 1977). The obvious result of this process would be an overall tendency to spread all debris evenly over the site area, and this is largely the result of behavioural process (natural forces tend to sort material according to size and shape).

While this is generally true, it must be recognised that each site consists of a core area with a high density of artefacts and a periphery area where the density of artefacts is lower. Finally there is a sharp drop of density marking the site "boundary". Where the site is flat this pattern is clearly present; where the site is located on the explicitly elevated landform such as a dune, this pattern is obliterated by the accelerated disturbance operating on the slope. As the result of site periphery overlapping with slope, and rapid emigration of artefacts away from the site that operate in this zone, destruction of the original pattern proceeds from outer towards inner site area. Therefore while the dramatic destruction can be observed in site periphery, its inner area may be relatively unimpaired.

Among the sites included in this project a degree of stratification is present. On the site G archaeological material is buried to about one metre from the current surface of the dune. A high density of artefacts on the surface (up to 1000 objects per 1m^2) and some taphonomic observations suggests that this dune is rapidly deflating. Such a distribution of the archaeological material can only be explained by the fact that the dune was in the process of building at the same time as it was intermittently occupied by people.

This dune has probably developed as the result of sand being trapped by a small patch of reeds growing around the adjacent spring (Photo 4). The beginning of rapid deflation can be attributed to the spread of rabbits which decimated vegetation on the dune at the end of the last century (Wood 1984). The volume of water discharged by the spring has dropped in the last hundred years too, reducing the spring's ability to trap the sand and stabilise it by vegetation cover. In any event, the dune and the spring itself are ephemeral landforms destined to be erased from the landscape. The archaeological site located on and developed in response to this attractive but unstable setting is equally ephemeral and destined to total destruction. The temporary burial of the archaeological material does not ensure the long term preservation of the site.

Sometimes the archaeological material is buried 3-10 cm below the current surface (sites: B, H, ST). The artefacts buried in the shallow deposits accounts for less than half or one third of the archaeological material on the site (excluding site G). This suggests that there is very little sedimentation of the natural deposits on the sites. Recently, the rate of deposition is lower or equal to the rate of deflation. The bulk of material buried in the soil is often within the first 3-5 cm under the surface. Below this depth the number of artefacts drops sharply and often there are none beyond 10cm. Such shallow deposits, at least partially, must be accounted for by post-depositional vertical displacement (eg. trampling).

These processes and resulting archaeologial patterns provide some guidelines to the developement of a sampling strategy.

4. Pilot sampling: exploration of inter-site variation and intra-site uniformity.

Sampling of the surface site does not need to be performed in a blind manner. For all practical purposes it is advisable that the apparent features of the archaeological scatter are taken into account when a sampling strategy is planned. A clear distinction between high scatter density in the core area and low density in the site periphery is observed on many mound spring camps. It appears that the bulk of archaeological material is deposited in the inner (core) area of the site. The core area seems far less distorted by natural post-depositional forces than the site periphery. By all reasonable assumptions, the wealth of evidence reflecting site character (as represented by assemblage of stone artefacts) should be found in the core, high density area. While targeting this inner site area, I was impressed by its manifest uniformity regarding an even spread of artefacts and their attributes, such as the size of objects, and the types of raw material.

Adopting a flexible strategy and taking advantage of an easy access to surface archaeological material, I decided to begin pilot sampling. The pilot sampling was designed to assess the degree of the site uniformity. The test was based on three assumptions. The first was that, generally, it is highly unlikely that two or more $1m^2$ taken from different areas of the site can display an identical or very similar structure of artefacts. The second assumption was that the spatial pattern of the assemblages can be initially measured by the raw materials' structure. While such variables are not determined by formal typology, their spatial distribution largely results from human behaviour because different stone types are associated with different flaking technology, kinds of artefact and function (eg. sandstone is the preferred material for seed grinders, while chert and silcrete are preferred materials for tulas and scrapers). The third assumption was that site uniformity can be gauged by two factors, intra-site fit of sampled squares and inter-site contrast.

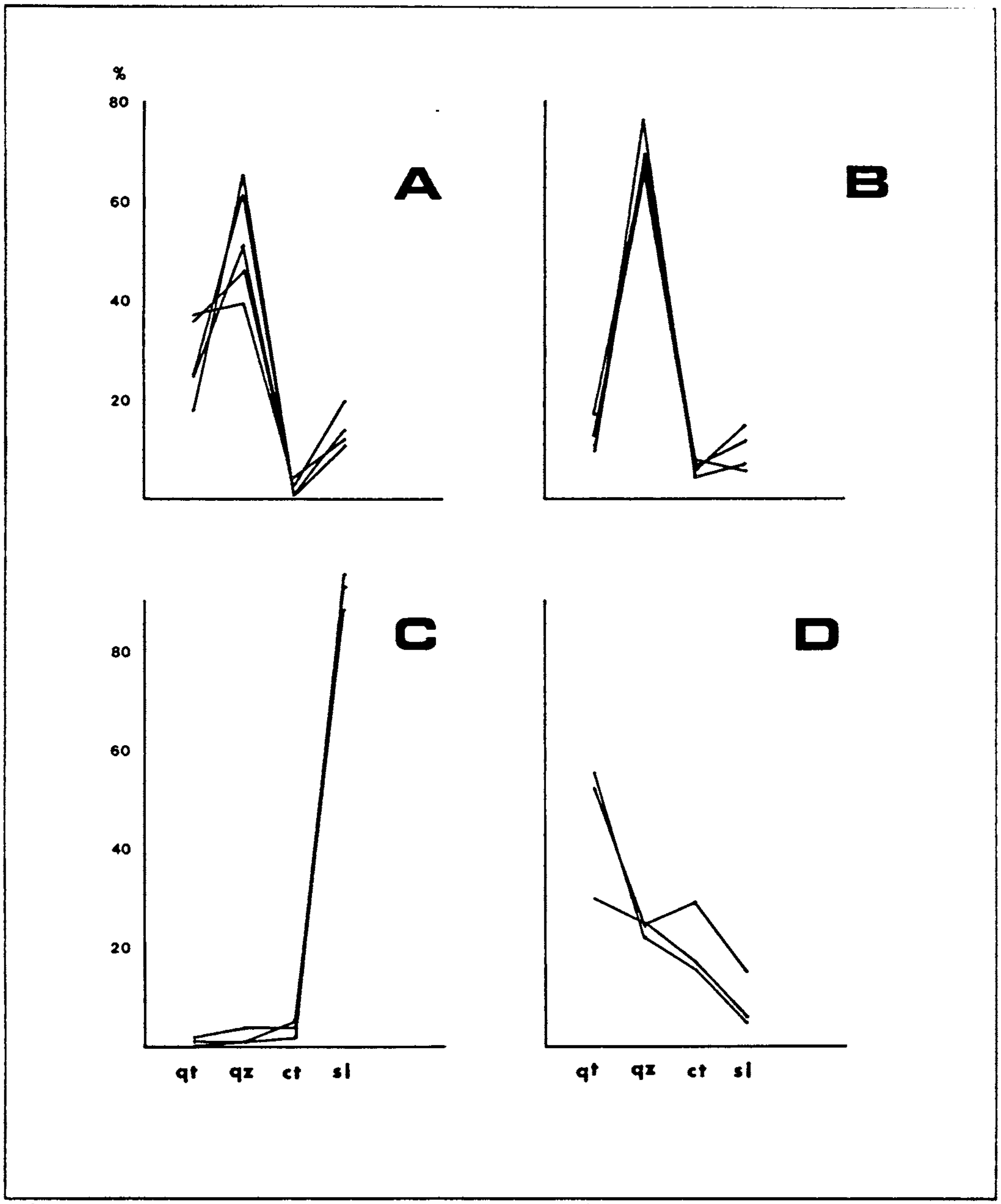

Figure 21. Percentage frequencies of different raw materials in pilot samples from sites A, B, C, and D (qt: quartzite; qz: quartz; ct: chert; sl: silcrete).

Working simultaneously on two sites A and B, located at the same springs and only a hundred metres apart, I attempted the first pilot sample. I collected all stone artefacts from 5 separate 1m^2 situated along the transect on site A, and from 4 different 1m^2 positioned randomly within core area of site B. I divided all artefacts from each square into four types of lithic raw material and ploted them on the frequency graph (Fig. 21, p.126). This test demonstrates that there is high degree of uniformity within the sites expressed by intra-site fit and inter-site contrast. A similar pilot test was subsequently carried out for all remaining sites where all stone artefacts were collected from 3-5 separate squares (Table 5, p.136) and relative frequency of raw material types ploted on the graph (Fig. 21, p.126 and Fig. 22, p.128).

While pilot sampling was adopted to test uniformity in the core area and consequently to select appropriate sampling strategy, it also provided a basis for assessing internal structure such as the dichotomy of core and periphery, and site dynamic such as slope effect and fluvial disturbance. These issues are discussed in the next chapter (VI).

The results of the pilot study suggested that a relatively small sample from the inner site area should well represent the structure of an assemblage on high density sites. However, I believe, that the occupational surface must contain some clues related to the distribution of artefacts, site structure and therefore, site character where both natural and behavioural components can be reflected. Many features on the occupation surface are likely to be larger than one 1m^2. In order to discover such features several neighbouring squares must be sampled. By all ethnographic accounts an area of 10 metre square (100 m^2) is very small for a camping site (for instance, one tightly clustered camp of seven households of Kung Bushmen covers area of 900 m^2, (Yellen 1977; Gregg et al. 1991); Hadza camps vary from 550 m^2 to 1250 m^2 with typical space between households being 4-7 m, (O'Connell et al. 1991); in Central Australia households are often 25-45 m apart (O'Connell 1987; O'Connell et al. 1991). Using this as a guideline, I adjusted the sampling size at particular sites aiming to uncover an area of occupation surface that was large enough to provide these hidden clues, but also reasonably small to avoid assembling a large pool of redundant data.

I was however willing to obtain samples that were too large rather than too small. Two extremes are illustrated by sites D

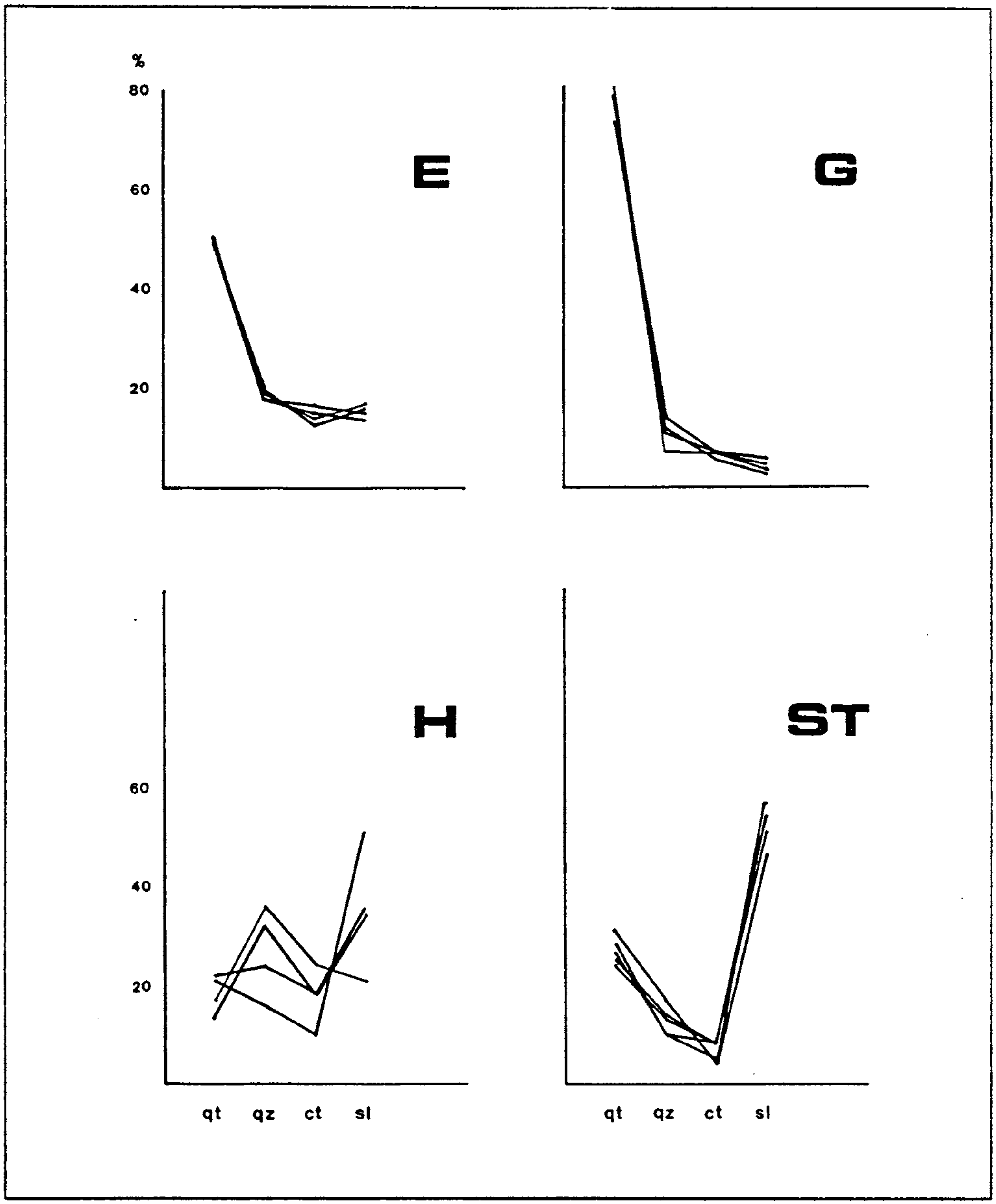

Figure 22. Percentage frequencies of different raw materials in pilot samples from sites E, G, H, and ST (qt: quartzite; qz: quartz; ch: chert; sl: silcrete).

and ST. On site D a large portion of the high density area (278 m^2) was sampled. This was justified by the fact that site D is, as a whole, low density and square to square variance must be much greater than on high density sites. Such variance is reflected in the pilot sample (Fig. 21, p.126). In order to furnish a better representation of an assemblage structure I considered it necessary to obtain a large sample from site D. Site ST was sampled only by 8 units ($1m^{2}$) located along the transect cutting across the dune. The pilot sample demonstrated a very low variance in the assemblage structure in spite of several squares being located on the slope (Fig. 17, p.117).

5. Sampling procedures.

A sample is a group of things taken from a larger group called the POPULATION and used to calculate the characteristics of the larger group. The word SAMPLE is derived from the Old French 'essample' meaning example. In statistics the sample is a representation (example) of the population. Sampling involves three procedures: 1) working out the size of the sample to furnish adequate representation; 2) selecting the type of sample; and 3) establishing the means of measuring the sample characteristics.

The volume of writings concerned with sampling in archaeology gives an impression that sampling has become the hard core of archaeological practice (eg. Mueller 1975a; Cowgill 1975, 1990, Dunnell and Dancey 1983; Fish and Kowalewski 1990). This must be applauded because for a long time archaeology was guilty of taking things according to their appeal rather than their associations and structures. The "grab-bag" collection of pretty things was the most notorious inefficiency of archaeological practice. The "grab-bag" reflected neither a real spatial configuration of the site nor a representation of the artefacts. However, those days are gone and sampling is an integral part of archaeology, though not all difficulties and errors are resolved by a pledge to proper sampling (Thomas 1989).

Although sampling in archaeology is often associated with random sampling, in this research I adopted a combination of different strategies. This approach was developed mainly in response to the observations that were made on the mound spring campsites prior to sampling and to evidence acquired through pilot sampling.

The sites included in this study were not picked by statistical methods, but selected arbitrarily according to several criteria. Priority was given to the smaller sites with a relatively high density scatter of artefacts and limited erosional damage. I considered it desirable that at least some campsites selected for the study were located at the same spring (sites: A & B; D & E). An additional criterion was the consent of the Arabana Aboriginal Community (for example the research in the Hermit Hill area was restricted).

Despite the mound spring campsites being selected, and not randomly drawn, they still provide a fair representation of the camping sites at the springs. In the area of this study 27 mound spring campsites are present (24 according to Hughes and Lampert 1985), 7 of them (about 25%) are included in this study. This selection is skewed somewhat towards smaller sites with a higher density scatter (compare Table 4, p.103).

In this study several populations of artefacts were sampled, each associated with one particular campsite (this is a clear example of cluster sampling; Mueller 1975b). Such populations of artefacts can be regarded as the simplified representation of the campsite. In this view several other aspects of the sites are assumed to be less important. Features such as landform and character of the soil, the number and structure of the fireplaces, and the overall configuration of the artefacts within the site were recorded and measured only as additional evidence providing spatial and geomorphological background for the population of the stone artefacts. This focus on stone artefacts is deliberate, but not the only possible approach to the study of archaeological sites (eg. Vita-Finzi and Higgs 1970; Jarman 1972; Welinder 1978; Fletcher 1990).

I believe that stone artefacts in the site context provide the most tangible, abundant and detailed evidence of the past human behaviour. Stone artefacts reflect technology, availability and selection of stone material, flow of stone material and products in and out of the site. They document some specific and generalised activities (eg. seed grinders and retouched flakes respectively). Interestingly enough some attributes that are not related to formal typology such as weight/size, and raw material types are significantly different among the different populations of artefacts. This suggests that the population of stone artefacts offers a solid base for inferring some aspects of the past human behaviour. The significance of these 'neutral' attributes is that they counterbalance the inevitable bias generated by an archaeological classification of artefacts.

Eight populations of stone artefacts were sampled (7 mound spring campsites and 1 non-spring campsite: C). The intent of this sampling was to draw a number of specimens with the view that distribution of the various attributes among specimens in the sample would reflect the pattern of distribution in the whole population.

Specimens were not drawn one by one in a random manner but were taken in groups from squares ($1m^2$) from different areas of the site. This method of sampling provides some probabilistic control over the mode of spatial distribution of attributes. The distribution of attributes in space can significantly vary between different areas of the site, and this is most commonly the case in archaeology. Such a distribution can also be uniform over the site area and this is a peculiar characteristic of many mound spring campsites (with provision for the site periphery).

Archaeological sampling must accommodate spatial variation because people conduct different activities in different places (eg. Gould 1971; Hayden 1979a; O'Connell 1987; Binford 1987c). The most obvious example of such a distinction is on-site and off-site archaeological evidence of activities (Thomas 1975; Foley 1981). It is also known that collecting most food and other resources is carried out off-site, while some food processing and craft-work is customarily performed within the habitation site. This study is not only concerned with the acquisition of a representative sample of assemblages (with recognising intra-site spatial variability), but also the unique character of mound spring campsites.

For the purpose of sampling each site was divided into squares, 1 x 1 m, each with its own unique number. These squares became the standard unit of sampling allowing for easy comparisons of the samples within the site and between the different sites. This method was designed to draw a number of specimens from the population and also to explore the distribution of attributes over the site area. Such exploration was not devised to provide a systematic spatial layout of the site, but to furnish sufficient representation of assemblages. It also must demonstrate that variation is significantly lower within assemblages than between them (this question is further examined in chapter VI, compare Fig. 21, p.126; 22, p.128; and 25).

In the last two decades, surface sampling in archaeology became almost equated with probability sampling, where focus has shifted from sites to a landscape (Dunnell and Dancey 1983; Fish and Kowalewski 1990). Site sampling is also often approached from the probability paradigm. However, in this research there are several reasons in favour of a method less dependant on the pure probability of drawing sample squares.

1) It was desirable to sample the core of the site only. Random sampling of the site periphery and the slopes was avoided because of the distortion in number and distribution of the specimens in this area.

2) However, the relationship between the site core and its periphery can be explored by deliberately locating sampling units. Such exploration was undertaken on site B.

3) The process of disturbance on the slope can also be explored by a systematic sampling of different areas of the slope. Such a study was attempted on site G.

4) In order to obtain a sample of an occupation surface the area equal to several tens of square metres must be considered. For this reason it is desirable to group the sampling squares in a single block. This method proved to be fruitful in discovering some discrete features and some gradual differences within and among the squares (compare Binford 1987c). Two examples are: a) a large number of remnant fireplaces were discovered on site B,

and b) the tendency of artefacts to group in 2-3 m clusters on site H (Fig. 10, p.109 and Fig. 12, p.112). These spatial features could not have been uncovered by transect or random square sampling.

The mound spring campsites offer a peculiar challenge to sampling. These sites are characterised by a highly uniform and very dense scatter of artefacts (Fig. 5, p.54). Such density and distribution of artefacts suggests two guiding principles. Both are unconventional and inapplicable in most archaeological situations: 1) a little sample taken from the site-core area would be sufficient and representative, and; 2) the site periphery should not be sampled in a bona fide random draw of squares.

The first principle raises the problem of sample size. From the statistical point of view a large sample represents the population in a more reliable way than a small sample. However, in scientific practice it is often necessary to reduce the sample size to make the research viable in terms of time and money. Another reason to limit the sample size is this; above a certain size the further increase of a sample brings greatly diminished returns which in practice may be negligible. There is no simple statistical rule to determine where the sample size is becoming too large and the data pool is practically redundant; this depends rather on the nature of evidence being explored by statistical methods.

When site uniformity is proved and the density of scatter is about 100 artefacts per $1m^2$ it may be sufficient to sample only several squares within the site-core area. Because the artefacts deposited here resulted from many occupational episodes, sampling the one small area is equal to random, one test sampling of many, probably several tens or even hundreds, single camping events.

The second principle highlights the problem related to the research goal. In this research the purpose is to obtain a representative sample of artefacts from each mound spring campsite selected for the study. Any sampling undertaken beyond this goal was to prove and demonstrate the homogeneous distribution of artefacts in the site and to understand the site dynamics (deflation, slope erosion, displacement of artefacts).

The above considerations lead to the adoption of three sampling methods used in different combinations. These methods are:

1) Transect. Sampling where single squares ($1m^2$) are systematically located along the transect. It is useful in assessing site uniformity and discovering distortion on the boundary of the site core and its periphery. This technique was employed on the sites where the archaeological material is deposited on the slope and subject to gravity displacement (sites A, C, G, ST). In addition, transect sampling on the slope provides a valuable insight into the site's post-depositional dynamics.

2) Randomly Scattered Units. Squares ($1m^2$) randomly located over the site area were designed to assess site uniformity. However, they do not provide an insight into the pattern of occupational surface and distribution of some discrete features larger than the sampling unit itself. The single sampling units scattered over the site area were employed as the control samples on the sites where no transect sampling was made (sites B, D, E, H).

3) Block-area. A block of squares ($1m^2$) covering an entire small area in the shape of a square or rectangle. It was adopted as an effective method of sampling very dense scatters of artefacts representing palimpsests of many occupational episodes. A small area containing several tens of single square metres provides a good resolution of an occupational surface where some larger discrete features and gradual variations are present. Because the different single camps were located within other parts of the site, the block area sample represents various fragments of these camps. In other words, in the high density sites, near squares represent a similar probability of variance as distant squares. Block-area sampling was employed on all but the site ST.

Actual sampling involved three basic techniques: a) collecting surface material by hand or brush and small shovel; b) sieving by 2.5 mm sieve, and; c) excavation.

Collecting artefacts by hand was mostly used for the removal of large to medium-size objects. This method was also used when the position of individual objects was recorded within a square and ploted on a plan. Small artefacts were swept with the brush and small shovel and sieved always using 2.5 mm sieve. While small objects were collected from the sieve, tiny flakes and flake pieces were taken together with other non-artefactual small objects remaining on the sieve and separated later in the laboratory.

Excavation was conducted routinely on at least one of the squares subject to surface sampling. In addition several fireplaces have been excavated in different parts of a site. Excavation was always carried out within 2.5 cm or 5 cm spits. The 2.5 cm spits proved useful in examining depth of archaeological deposits on the sites where the ground was hard and compacted. In such situations archaeological materials were restricted to the surface and 3-10 cm beneath the ground with a sharp drop in their number below 2-5 cm from the surface (eg. sites A, B, C, D, E). The fine 2.5 cm spits permitted some resolution of change in vertical distribution of artefacts in such shallow deposits.

Where the soil was soft and loose, excavation in fine spits was very difficult and therefore 5 cm spits were used (eg. sites G, H, ST).

Squares without fireplaces were excavated in their entire area, one spit at a time. Squares with fireplaces were divided into two parts to provide cross-section through the hearth and each half was excavated separately. (Number of squares excavated on each site - A:4; B:10, C:2, D:5, E:1, G:5, H:5, ST:5).

Excavation was routinely followed by augering to probe into underlaying stratum. Auger tests were also made in other areas within and away from the squares subject to surface sampling.

The excavation and auger tests demonstrate that in general archaeological materials are on the site surface and in subsurface deposits to about 10 cm below the ground (excluding site G). Occasionally when artefacts are found in the irregular pockets of soft loose soil they may be deeper to about 20 cm from the surface. If the substratum is hard and compact (eg. site A) no artefacts are found in subsurface position. Fireplaces often visible on the surface, usually extend deeper into the ground up to 30 cm.

Archaeological materials collected from excavation and surface included stone artefact, bone, egg shell, and ochre. Charcoal and soil samples were collected only from excavation.

A summary of the surface sampling is provided in Table 5.

Table 5: number of units ($1m^2$) sampled within each site

site	pilot sample	block area sample	slope/ periphery sample	total
A	5 *	15 *	-	20
B	4	52	100	156
C	3 *	89 *	-	92
D	3	278	-	281
E	4 *	31 *	-	35
G	4 **	21 **	3	28
H	4	49	-	53
ST	5 **	-	3	8

* slope only; ** including slope

CHAPTER VI

INTRA-SITE UNIFORMITY VERSUS INTER-SITE VARIATION

"The wider the range of different general activities performed at a particular site, the greater the likelihood is that the by-products of each task performed in relation to each of these activities have become detached from the original locus where each task was carried out."

Richard A.Gould 1980:197

1. Introduction

Archaeological sampling, as described in the former chapter, was applied to formalise and quantify observations that can be readily made on surface sites. For example, the density of archaeological scatters can be readily observed and expressed in descriptive terms as more and less; data retrieved through sampling allows density to be expressed in actual figures (eg. 50 or 100 objects per 1m^2). Unlike excavations, where sampling is almost a blind probing through buried strata, surface site sampling can be described as a process of measuring features that are already recognised and defined. Most sampling in this project translates observable characteristics of the sites into quantitative statements. This process can be described as the provision of quantitative proof.

For the question pursued in this research, the most important observable characteristic of the mound spring sites is that the intra-site variability is minimal, while the inter-site variation is large. In this chapter, I will demonstrate and discuss how data procured through archaeological sampling supports this observation.

2. Intra-site variability

A. Site structure.

It should be remembered that the assemblage of artefacts and its configuration in space can be, and often is understood as the practical representation of an archaeological site. From drawing on numerous archaeological and ethnographical examples, one is led to expect that the spatial configuration of artefacts displays a structure. In fact, spatial configuration itself is equated with structure, regardless of whether it is caused by human factor, natural forces, or a combination of both.

One of the reasons for archaeological sampling is that site structure can be analysed and at least partially explained in terms of human behaviour in the past. Yet, it appears that most of the sampling techniques are unable to unveil the site structure (Kent 1987a). The only sampling strategy equipped for such tasks is a full-coverage collection, excavation and recording (eg. Hayden 1979a; O'Connell 1987; Binford 1987c; Nicholson and Cane 1991). Most of the random sampling techniques are likely to overshoot one or more vital features of a given site structure. Sampling based on the actual knowledge of spatial configuration of artefacts is usually designed to pick up discrete entities (Mueller 1975a).

In relation to surface sites, sampling is required to resolve specific problems. Namely, some readily observable structural features must be taken into account when the sampling strategy is being designed. It is no good to pretend that nothing is known about the site structure and to force a 'blind', random sampling strategy. When the observed site structure is considered, sampling must, for practical purposes, take the form of an acquisition of quantitative proof. The sampling procedure can then be described as a selective documentation of observable patterns.

In terms of artefacts and space, site structure can display three types of arrangements 1) discrete features (eg. concentration of artefacts or specific kinds of artefacts, clear areas, special facilities such as huts, roasting pits, and fireplaces); 2) gradual density increase/decrease of artefacts or specific kinds of artefacts, and; 3) discrete concentrations and/or gradual density increase/decrease of specific attributes which are not readily visible (eg. different anatomical parts of faunal material with various cutting or gnawing marks, different proportion of retouched artefacts of several stone types). None of these kinds of arrangements is exclusive. Numerous ethnoarchaeological examples suggest that such arrangements do occur together with variable permutations (eg. Gregg et al. 1991).

However, the archaeological visibility of site structure is usually obscured by three powerful factors. The first is that a thin data matrix may not allow for a conclusive observation, measurement of structure and its statistical expression; Hayden (1979a) experienced this problem with two small campsites Ngaru and Walu (chapter III). The second factor is that a thick data matrix commonly results from repetitive re-occupation, recycling and the changing arrangements of a habitation space (often regarded as distortion eg. Spurling and Hayden 1984:225). In such a situation, the multiple superimposition of material is combined with an ongoing occupational disturbance. This is what we encounter on the mound spring sites. The third factor is post-depositional processes which work towards the destruction of an original site structure and imposition of another, geomorphological pattern. These processes tend to re-order artefacts according to weight and size, by depositing heavy material in low formations such as gullies and creeks, transporting medium-size artefacts by gravity and fluvial forces, and 'winnowing' out the smallest artefacts from their original context. Such a process is visibly obliterating the periphery of the mound spring sites.

Despite these obstacles, it is expected that some aspects of site structure can be detected. The only apparent structural feature of the mound spring sites is a difference in density of scatter over the site area.

B. Core and periphery

Mound spring sites seem to have a homogeneous distribution of artefacts over the site area. The only visible structural feature of each site is a high density core and a low density scatter on the site periphery. A poorly defined area between the core and periphery is characterised by a gradual decrease in density. This simple arrangement is almost an archetype situation, best represented by site B located on the flat area (Fig. 9, p.108). On many other sites this pattern is obscured by the slope effect, which will be discussed later. I use site B as an example to discuss ralationship between site core and its periphery.

Site structure should be reflected by variability between different areas of the artefactual scatter. Variability can be expressed by several different features. The quantity of artefacts per measured unit (eg. $1m^2$) is one of these features. On site B 56 $1m^2$ sampling units were located in the high density area and 100 such units in the site periphery. While the mean number of artefacts per $1m^2$ in the core area is 213.6, in the site periphery it is only 1.5. The density of the scatter is therefore 140 times lower in the site periphery, demonstrating a strong contrast between the core and the outer area of the site.

Another measure of diversity is the proportion of four types of raw material between different areas of the site. On site B, quartz is consistently the most common type of material, followed by silcrete, quartzite and chert. In only four out of the 56 squares are quartzite artefacts more numerous than silcrete artefacts. Proportions of raw materials can not be calculated for one hundred squares on the site periphery (small numbers of artefacts), however, when these hundred squares are taken as one unit, it shows that, here too, quartz is dominant. Although, in contrast to the core area, there is the following order of other types: quartzite, silcrete and chert. So, silcrete is second in the core but the third in the site periphery.

Tools consist of between 2% and 11.5% of artefacts per square within the high density area (proportions of tools calculated for 2m^2 units range from 3.3% to 8.2%). In the site periphery (10m^2 unit) tools make up 15.1% of artefacts.

While there are obvious differences in density and proportion of stone types between site core and its periphery, other variations seem to be marginal. In order to explore the variability of these attributes across the site, correspondence analysis was carried out for 57 sampling squares (100 squares at the site periphery are taken as one single unit disregarding the difference in size and density).

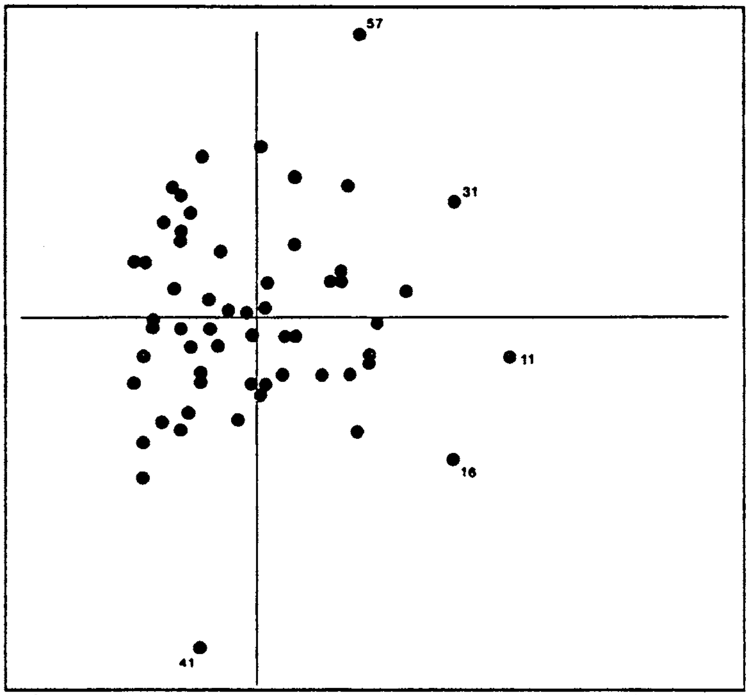

Figure 23. Correspondence analysis: 57 squares from site B (only squares detached from the cluster are numbered). Variables are listed below, p.144.

Nine variables used in this analysis are the abundance of: 1) quartzite; 2) quartz; 3) chert; 4) silcrete; 5) cores; 6) backed blades; 7) scrapers; 8) retouched flakes, and; 9) other tools (all raw counts, Appendix Table A2). The result shows (Fig. 23)[1] that there is no evident structure in the data; all squares tend to centre around the most abundant raw material - quartz. Squares with a higher proportion of tools adhere to the upper-right part of the cluster, while those with a lower proportion of tools are found in the lower-left part. Some squares characterised by less common attributes, such as backed blades and cores, are protruding from the cluster. A similar result is

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[1]. Figures 22 and 23 show only objects (squares) to demonstrate in a graphic form that there is no readily discernible structure in coresponding tables of data.

produced when the most abundant material - quartz (second variable) is removed from the analysis (Fig. 24).

It must be remembered that tools are rare. While some tools such as retouched flakes are distributed almost equally across the site, others such as backed blades are scattered in a more erratic manner over the site area (eg. blades are absent in the one quarter of squares). These rare elements are over-emphasised by correspondence analysis.

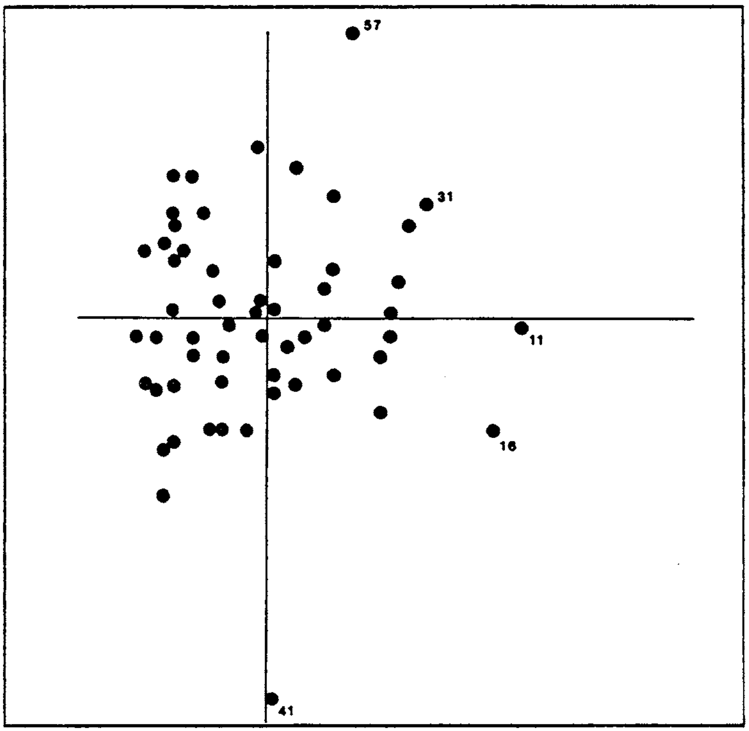

Figure 24. Correspondence analysis: 57 squares from site B (only squares detached from the cluster are numbered). Variables are listed on page 144.

It seems that the presence of rare attributes such as backed blades or cores is related, in a probabilistic manner, to the high abundance of artefacts within a square. Squares with large numbers of artefacts are likely to contain most of the rare attributes. However, a 10m^2 unit within the site periphery that can be taken as equivalent to one low density unit in the core area (152 artefacts against mean 213) shows relatively high proportions of tools (15.1% against mean 6%).

The difference between the core and the periphery of the site can be understood as a structural variation. In functional terms, it translates to a different use of core area in contrast to the periphery. Such a functional difference can be explained by several observations.

1) The low density scatter in the site periphery results from a different use of this area. By usage of stone artefacts

and accumulation of discard, it can be described as a low intensity area. It means that activities carried out here were such that produced less stone artefacts and of a different kind in contrast to the core area.

2) The higher ratio of tools to all other artefacts suggests that proportionally less reduction (knapping and/or resharpening) was performed within the site's periphery. This is supported by the fact that all flakes from the periphery are significantly larger (heavier) than in the high density area. This relation is illustrated in Table 6.

Table 6: site B: mean weight of flakes within core area and site periphery (three first groups of flakes only are included)

site area	small flakes up to 1.5cm	medium-size flakes 1.6cm-3cm	large flakes 3.1cm-4.5cm	N
core	0.32g	1.33g	7.75g	9655
periphery	0.39g	2.30g	25.60g	91

3) The presence of large numbers of small flakes (62%) as against medium-size flakes (38%), taken here as an indication of on-site reduction (chapters VII and VIII), is almost exclusively due to the size structure of quartz flakes (N 67) within the sample of the site periphery. Three other types of stone represent more balanced proportions, but the very small total numbers of flakes (N 19) prevent me from demonstrating a contrast between quartz and non-quartz flakes' structure. According to this measurement, within the core area both quartz and chert were intensively reduced, but in the periphery only quartz seems to be commonly flaked and retouched.

4) Silcrete is the second most common type of raw material within the core area. The largest numbers of backed-blades, scrapers and tulas are made of silcrete. The second largest number of cores and retouched flakes are also made of silcrete.

However, in the site periphery silcrete accounts for a small portion of raw material (5.3% versus 18.7% in core area).

What emerges from this analysis is that spatial variability within the core area is minimal. Clear variation is observed between the core area and the site periphery. However, a massive difference in the abundance of artefacts implies that site characteristics, such as proportions of raw materials, tools and other specific attributes, are overwhelmingly determined by the core area of the site. This is not to say that the site periphery must be disregarded, but for practical purposes in this research, the outer site area contributes only a marginal portion of data. If this contribution was fully utilised it could turn out that the proportion of silcrete on the site B is slightly lower and the proportion of quartzite slightly higher than in the core area alone. However, to provide material for such a minor correction one would need to collect data from 150-200 units as a numerical equivalent of one such unit from the high density area.

There are two other sites, D and H, located on a flat area. Another two sites, C and E, are located on a gentle slope. They all display a density contrast between the core and the periphery.

Site D shows a classical example of a thin data matrix with an overall density of 30.5 artefacts per 1m^2 (Fig. 5, p.54).

Site H is visibly disturbed by fluvial episodes and, accordingly, there is a more erratic distribution of attributes in the high density area (Fig. 11, p.111) and clustering of artefacts throughout the site.

The periphery of site C is larger on the slope above the core area, and truncated down the slope which becomes steep in one direction and merges with a stone outcrop in the other.

The artefact scatter on site E merged with the residual material of the gibber plain consisting of a high density scatter of pebbles which obscures archaeological visibility. The density of the artefact scatter decreases at the edge of the plateau.

Although an elaborate investigation of diversity between the core and the periphery was not carried out for every site, some examples demonstrate that site periphery corresponds to the general site characteristics. More importantly such a relationship can be illustrated by even sites with a low density scatter. Site C is characterised by a high proportion of silcrete and this feature is consistently represented by 86 out of 89 sampled units (the remaining three yield no artefacts). Site D is dominated by quartzite with quartz being the second most common material. This order is represented by 220 out of 275 units. With two exceptions, the order is reversed only within the units where the density drops below 50 artefacts. Less than a quarter of these irregular units are dominated by chert or silcrete and those squares tend to occur towards the site periphery.

A site structure with a central area of high density scatter and a periphery with low density discard can be interpreted in various ways. The possibility that the high density area may have been a refuse zone is one such interpretation. However, the uniform distribution of artefacts and many fireplaces observed in the high density area on site B, suggests that another explanation is more appropriate. The core area of the site can be seen as the most favoured for camping and associated activities that generate stone artefact discard. During repetitive occupation, the site area was used in such a manner that camping activities were most often located in or near the core, high density area.

This behaviour of focusing occupational activities in one particular area of the site can be explained by a set of circumstances. It appears that the proximity of a camp to the source of drinking water was an important factor in selecting the camping location ('the camp was sited away from the water hole, in order not to disturb animals coming to drink' - writes Macfarlane 1978:50 referring to Rawlinson Ranges; also Gould 1968:118-120). My impression is that the optimal distance for the mound spring campsites was 200-300 metres from the spring; the mean for 24 sites recorded by Hughes and Lampert is 222 metres from the spring.[2] Such a distance is often within a creek channel which does not provide a good camping ground. The creek is occasionally flooded, sometimes soggy, and always with very high salt contents. Ideal for occupation were the small elevated landforms within the creek course, such as local sand dunes or the creek bank covered with sand-sheet. The availability of such landforms that were the right distance to the spring and with preferred sandy substratum was limited. This may be a reason why people camped on the same spot time after time.

Focusing occupation on the core area can be explained by the most preferred area within site limits. On site B the core area coincides with the highest ground, still merely 3 metres above the current creek bed. The core area has been covered with a thin deposit of fine gravel with a sandy matrix. Further away, this deposit slopes to the creek at one end, and thins down to a bare calcrete substratum at the other end of the site periphery. On other sites, where elevation is more pronounced, the core area usually coincides with a flat and/or top section of a landform, while the periphery overlap with the slope.

The site periphery can be seen as the transitional zone where activities of low intensity (in relation to stone use and discard) took place. Further away there is another significant drop in density with one stone artefact per $10m^2$ or even larger area. Within about 1 km around the site, small concentrations of stone artefacts can be found. Often they are isolated knapping floors related to the procurement of stone material. There may be also other activity areas. For example, it has been recorded that the stripping of bark from a tree can be associated with the instant manufacture of chopping tools used on the spot and discarded near by. Such tools are rarely found on habitation sites (eg. Thomson 1987; Gould 1978; Hayden 1979a). By virtue of isolation, such an off-site activity area can be treated as a site in its own right (Photo 9 and 10). In this context, the site periphery can be understood as a practical parameter of a

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[2]. Nicholson and Cane 1991:318 quote 70-169m distance from water for Western Desert campsites.

habitation zone; further beyond is a foraging and procurement territory (various sources quote a radius of about 10 km of the camp as area of intensive, daily exploitation by foraging people in desert areas (eg. Lee 1968; Woodburn 1968; Gould 1980), (Fig. 3, p.29).

C. Site periphery and slope.

The site periphery often coincides with a slope. Here, the most dynamic process of site disturbance is visible. The forces of gravity with the assistance of wind and water are largely responsible for the displacement and selective re-deposition of artefacts. This process is best represented on site G. Located on a small dune, site G is bordered by a low area within the creek bed. The core area of the site is associated with the top of the dune, and the site periphery is located on the slope. While flat site B can be seen as static, site G can be understood only as a dynamic situation.

Although a significant portion of artefacts is on the surface, many are still buried in the dune (down to 1 m below the current ground surface). When artefacts on the slope surface are being constantly displaced, others are emerging from the deflating dune.

In the upper section of a slope, characterised by steep inclination, larger artefacts are under-represented because they tend to roll or slide down the slope. Simultaneously, small and medium-size artefacts emerge from the dune in a much higher rate than the large ones. On the middle, gentle section of the slope, larger artefacts have accumulated because their down-slope movement is greatly reduced. Here, in the site periphery, only a minimal quantity of small artefacts can emerge from the dune and thus over-representation of larger objects is visible. The constant movement of very small artefacts down the slope (wind and water) results in their accumulation in the lower section of

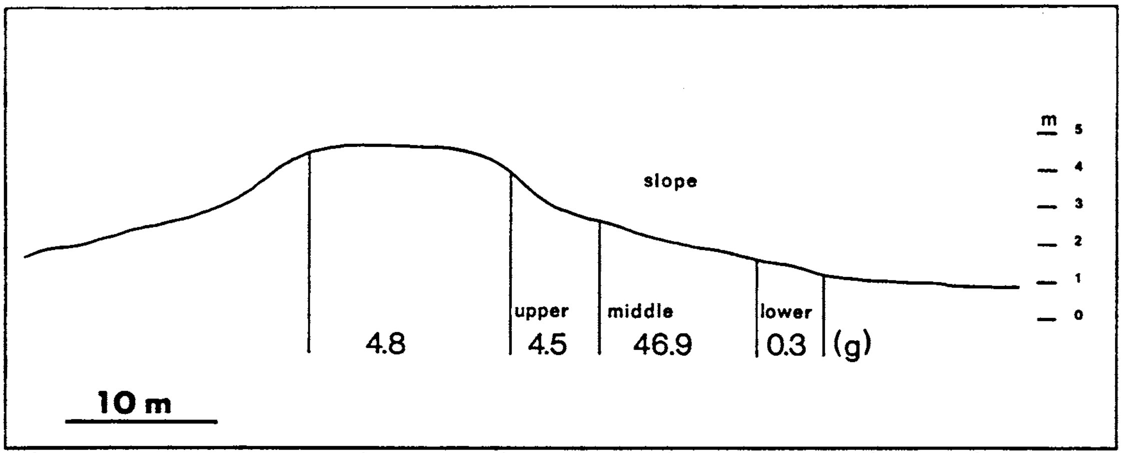

Figure 25. Schematic profile of site G showing different sections of a slope and mean weight of stone artefacts within each section.

the slope, at the foot of the dune, where the gravitation-pull for large objects is very weak. Here, very small flakes and shatter accumulate and are re-buried within a highly dynamic watercourse. Rapid sedimentation leaves only a portion of objects on the surface. But this sediment is being washed by occasional rains down into the creek bed.

The difference in the artefact-size structure across the slope can be expressed by the mean weight of all stone artefacts, which is 4.5 g for the upper section, 46.9g for the middle section, and 0.3 g for the lower part of the slope (Fig. 25).

These results are similar to Rick's study (1976) of a downslope movement of artefacts on archaeological site. General rules are that a) the steep slope (eg. upper slope of site G) tends to be cleared of artefacts with large objects being moved more readily than small artefacts, due to strong gravitation-pull, and; b) the gentle slope (eg. middle slope of site G) tends to retain artefacts longer with small objects being moved more readily than large artefacts, due not to gravity itself but to the action of wind and water. Consequently large objects tend to be correlated with low slope angle, and small objects with high slope angle.

Furthermore, my study suggests that when low slope angle still decreases gradually towards flattish land surface (eg. lower slope of site G), its ability to 'pull-in' large objects tend to diminish. It must be clear that local circumstances such as site elevation, slope gradient and profile determine taphonomic processes on the slope and consequently distribution pattern of artefacts. For example slope profile in Rick's study is fairly straight, relativelly steep all the way from a shelter to the foothill (10^0-44^0), and total elevation of about 30 m (Rick 1976:Fig.3,p.137). In contrast the slope profile analysed for site G is significantly 'curved in' with a steep but short upper section, and long gradually decrising middle and lower slope sections. With total elevation of 3 m the steep upper slope represents about 1 m. This is enough to induce downslope movement of large artefacts but not enough to to keep them rolling on a gentle slope for more than several metres, which roughly represent the middle slope.

Size sorting of artefacts is clearly a structure of natural (eg. geomorphic) origin. In other words, the site periphery displays very little, if any, spatial structure reflecting human behaviour. It is important that the structure of natural origin can be distinguished from the structural arrangement of human activities within the habitation space. In this instance, the surface archaeological material on the slope is useless for learning about the use of residential space in the past. This should be read as a caution that other surface sites located on a slope will also display a structural pattern of natural origin.

In fact, site ST shows a similar tendency of natural disturbance. Here, material on the top of a dune and on the flat section of the slope show a high proportion of small flakes to the medium-size flakes (70% top and 69% flat section of the slope), reflecting an on-site reduction of stone material. This proportion is much lower on the middle slope (59% and 53% for upper and lower part of the middle slope respectively; see Fig. 17, p.117).

It can be concluded that for the aims of this research, slope sampling should be approached with special caution, if not avoided altogether. A relatively undisturbed periphery-scatter on the flats contributes very little to the knowledge of a statistical structure of an assemblage. When it is disturbed by the slope effect, site periphery can show distortion (eg. site ST) or outright obliteration of a behavioural pattern (eg. site G).

D. Vertical variability.

To a lesser degree the distribution of archaeological material on flat surfaces is also disturbed. Wind appears to play an important part in this process. It has been observed that months after the original sampling was conducted, some material emerged on the surface of previously cleared squares. This may be partially due to wind moving small artefacts across the site, but it is obvious that a portion of this material emerged from below the surface as a result of deflation. To explore this process I collected archaeological material from the surface of some squares a second time, 18 months after the initial collection took place.

As expected, material in the second collection was significantly smaller. The size difference can be expressed by the mean weight of small and medium-size flakes combined within the first and second collection (only these two groups of flakes provide sufficient data for statistical analysis). In addition, some excavated squares were analysed to measure the size difference between surface and buried material. Table 7 (p.151) provides comparative data for sites B and G.

It seems that small artefacts are under-represented on the surface. In part, it can be explained by the wind removing the smallest artefacts from the site. It may also reflect a more complicated process. It has been demonstrated that in surface and shallow archaeological deposits larger objects tend to accumulate close to and on the surface, while smaller objects can penetrate further down into a substratum (Baker 1978; also Stevenson 1991). If this fact is taken into account, it appears that small objects may be under-represented on the surface in relation to large objects. At the same time they are over-represented in buried deposits where large objects are rare.

On site G, for example, large artefacts have accumulated on the surface by an additional factor of the dune's deflation. During years of deflation, which removed 60-70 cm of the dune's upper part (chapter III), these large objects accumulated on the current surface. Table 8 (p.152) illustrates a gradual drop in the size (weight) of all stone artefacts, unretouched flakes only (this allows some extra large objects such as hammerstone to be excluded), and bones.

Table 7: mean weight (g) of small and medium-size flakes combined on sites B and G, (in selected squares)

square	first surface collection	second surface collection	excavated collection
site B			
61/32	1.13	0.53	
68/33	1.33	0.48	
68/34	1.06	0.54	
69/34	1.14	0.65	
65/34	0.97	0.48	0.51
69/33	1.13	0.45	0.32
site G			
28/33	0.92	0.48	
29/30	0.91	0.37	
29/31	1.18	0.37	
29/32	0.91	0.46	
29/33	0.96	0.47	
29/34	1.06	0.49	
28/35	1.07	--	0.26 *

* this represents the mean for the first five spits where medium-size flakes are still relatively common (20cm down from the surface)

It is difficult to measure how much the assemblage represented in the surface collection is distorted by over-representation of large artefacts and under-representation of small objects. It is equally difficult to measure how the buried portion of the material is distorted by over-representation of small artefacts. However, for practical purposes this difference can be ignored, the main reason being that the buried portion of the assemblage usually (except site G) makes up less than half and often less than one third of the entire archaeological material. It is documented that neither proportions of raw material nor flake-size structure vary significantly between the surface and the buried parts of the site. Although a dominant proportion of small flakes against the medium-size flakes is over emphasised by buried material; and a dominant proportion of medium-size flakes is less prominent; the structure is usually preserved. While being aware of the fact that surface material is skewed towards larger artefacts, we can accept that, by virtue of its abundance, the surface portion of an assemblage structure provide satisfactory characterisation of the site.

Table 8: mean weight (g) of all stone artefacts, all flakes and bones on site G

collection	all stone artefacts	all flakes	bones
first * surface coll.	4.88	3.05	0.17
second * surface coll.	2.34	1.52	0.12
excavated coll. **	2.20	0.87	0.11

* first and second collection is made on the same 6 squares;
** excavated collection includes 9 first spits containing more than 100 stone artefacts each (45cm down from the surface).

3. Intra-site uniformity and inter-site variation

Sites B and G contribute most of the material for discussion in this chapter and represent two extremes. Site B is flatter, while site G shows a stronger contrast between the flat core area and the periphery on the slope. Archaeological material on site B is largely surface and the small portion (30% of total) covered with a few centimetres of sandy gravel seems to be a result of 'recycling burial' and decades of exposure to intensive stock traffic across the site. A large portion of archaeological material on site G has been buried (about 63% of the total) and an accelerated deflation only recently exposed some on the surface. Because of its geographical location, site B appears almost static with minimal vertical movement of artefacts and restricted horizontal displacement (the smallest flakes are mainly blown by the wind). Site G, on the other hand, shows the most vigorous process of deterioration and a massive migration of artefacts from their original context in the site periphery.

Other sites included in this study can fit in between these extremes with various specific problems of deterioration. Site A is on an elevated, narrow hill-like formation. Archaeological material is deposited exclusively on the surface without penetrating down into the hard compacted clay/calcium carbonate substratum. The landform is being deflated by water, carving deep gullies along the slopes (Photo 8) and artefacts are being dragged down to the bottom of the slope and re-buried in thick sheets of sand.

Site C is on a small sandy patch of the sloping gibber plain above a rock-hole. Lizard and rabbit burrows are common here and some artefacts are re-deposited in the burrows. The bulk of archaeological material is on the surface; there are some small pockets where it is covered by shallow loose sand. Artefacts tend to slide slowly towards the slope's steep edge.

Site D is on a flat high terrace above the creek. Archaeological material is on the surface only; some fireplaces are dug into hard clay/carbonate substratum. While there is minimal movement of artefacts, both edges of the site are being eroded. On the one side, the creek (when flushed with water) is gradually removing the terrace; on the other side, a little rivulet performs a similar task on a smaller scale.

Site E is on a gently sloping hill-top. The hill is built of sandstone and appears to be the most erosion-resistant landform. Although breaking along the edges, it has the best chance of surviving for some thousands of years. Artefacts are on the surface only.

Site H is on the flat creek bank subject to flooding. Archaeological material is on the surface and partially in the shallow soft soil that forms a thin crust when dry, but easily breaks to puffy dusty matrix. This soil, in combination with water causes material to be exposed and re-buried many times. Also, there is a visible re-arranging of material by water. Artefacts tend to form small clusters - a diagnostic feature of fluvial disturbance (Schick 1987; chapter III).

Site ST is on the dune covering a dry mound spring. There are two sections with a long gentle slope and one very steep section. A high density area is associated with the top of the dune and the upper to middle part of the gentle slope. There are some pockets where artefacts are buried in sand (up to 50%), but the bulk of material is exposed on the hard surface of the dune's core. The lower part of the dune is eroding especially fast due to stock traffic.

In summary, it should be noted that the core area of each site is largely the best preserved and least affected by destructive forces. It means that samples of archaeological material taken from the core area are the most reliable representation of the structure of an assemblage. What remains to be established is the degree of variability in the core area of the sites. To explore this aspect of site structure, correspondence analysis was carried out for 245 sampling units ($1m^2$) located in the core and periphery of all eight sites considered in this study (some units that were sampled exclusively for slope distortion and some analysed in the field for only raw material proportions are excluded). Nine analysed variables are the abundance of 1) quartzite; 2) quartz; 3) chert; 4) silcrete; 5) core; 6) backed-blades; 7) scraper 8) retouched flakes, and; 9) other tools (all raw counts, Appendix Table A3).

The scattergram (Fig. 26, p.156) shows the result of the analysis. It is apparent that sampling units from the same sites are clustered together. Clusters vary from very tight (eg. site G) to loose (eg.site C and D). Tight clusters represent high density sites (thick data matrix), while loose clusters reflect a sparse scatter of artefacts. The inset, in the left lower corner (Fig. 26, p.156), shows a mean scatter density for every site to demonstrate how the tightness of the cluster corresponds to the density of the scatter.

There is minimal overlapping between the clusters; each occupies its own space on the scattergram. The most evident incident of overlapping is that four samples from the site ST invade the peripheral zone of site H, while one additional square penetrates further into site H cluster area. This partial overlap, however, does not obscure the fact that ST tends to centre further down while H clearly gravitates up towards the centre of the scattergram.

Several squares protrude from their respective clusters. Most of these units are samples from the slope (eg. G158, G160) or periphery (eg. ST243, ST245) where the artefact structure is distorted. Some squares represent a very thin data matrix (eg. D102, D105) and others reflect distortions, such as erratic distribution of artefacts caused by the flooding of site H (eg. in contrast to other units from this site, H208 shows a very small proportion of quartzite and only one quartz artefact), (Appendix Table A3).

It is worthy of note that samples representing the assemblage from one site are very much alike, while samples from different sites are markedly different. Such minimal variability within the assemblages at each site and a clear variation between assemblages at different sites is a significant feature of mound spring campsites. Distinct intra-site uniformity gives us a high degree of confidence that site characteristics can be drawn largely on the basis of samples taken from the core of a scatter. I must emphasise that this is not a recipe for the handling of other archaeological assemblages. Such consistent intra-site

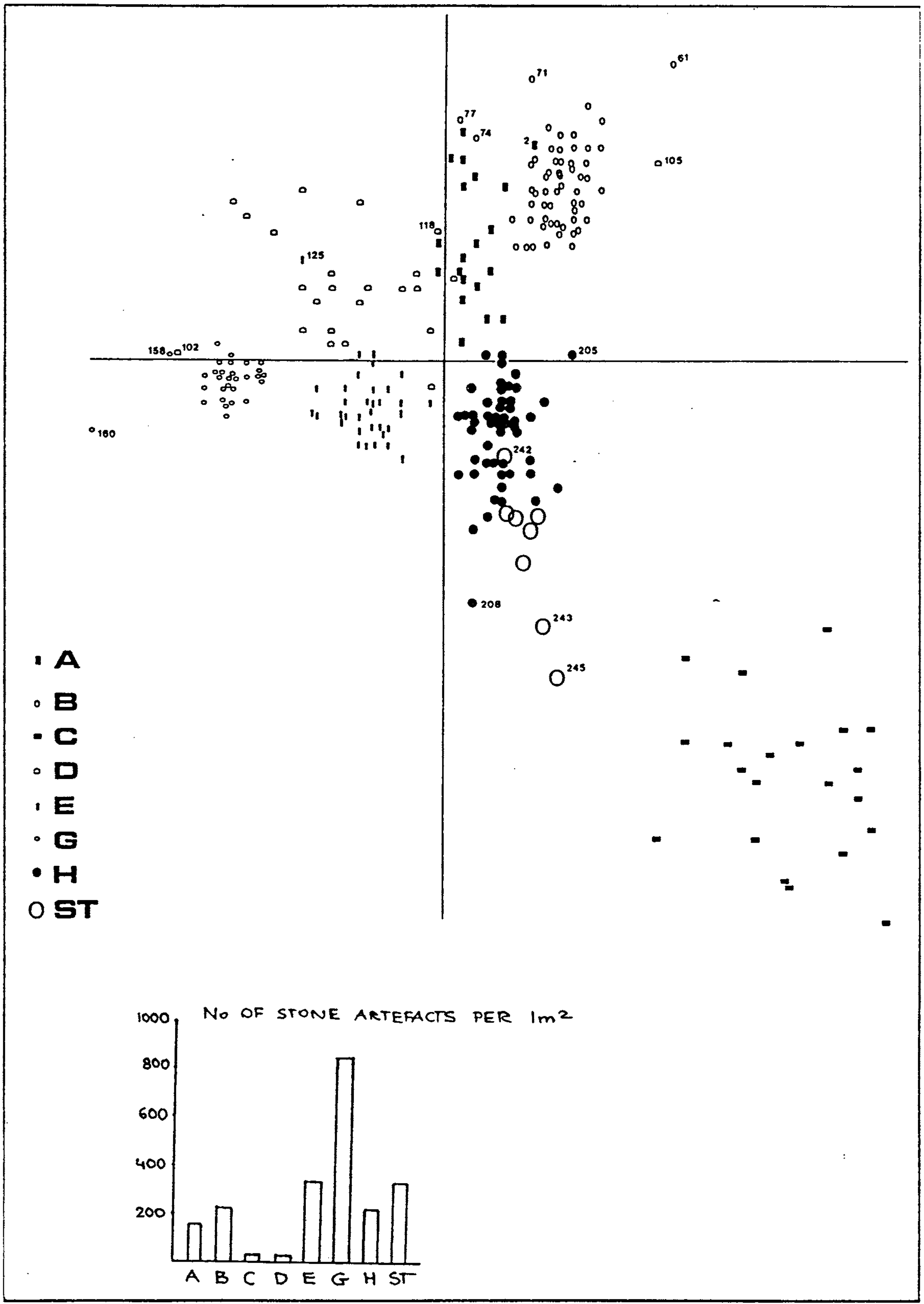

Figure 26. Correspondence analysis of 245 samples for eight assemblages. Variables are listed on page 154.

uniformity is a specific quality of the mound springs sites resulting from the unusual distribution of water and bio-resources, climatic condition and human life-strategy.

4. Conclusions

Close observation of the many mound springs reveals that convenient locations for camping are usually rare and small. Good camping locations are landforms elevated above the creek channel, preferably clear of surface stones, and ideally covered by a sand-sheet. Another important factor is the close proximity to water, usually less than 300 metres.

The mound spring campsites are characterised by the dense scatter of stone artefacts. Such scatters are homogeneous in a sense that artefacts and their attributes are spread evenly over the site area. Consequently, every area of the site is very much like any other area of the same site (allowing for distortion on the site periphery and on a slope). This is an outstanding quality of the mound spring sites and must be attributed to the large number of camping episodes superimposed one on top of the other.

In this study, a similarity is determined for the areas as small as one square metre. Such small units of testing can be applied in the area where the density of scatter is no less than about 100 artefacts per 1m^2. This fine resolution generally cannot be applied to the site periphery or to the slope areas where the density is lower and distortion in the artefact distribution is most severe. A strong similarity between small units demonstrates an even distribution of attributes through the site and confirms that a small sample from the inner-site area is representative for the site on the ground that the core area: a) contains the bulk of artefacts, probably above 90%; b) retains the most significant component of behavioural pattern in artefact distribution, and; c) is least affected by erosion which progresses from outer toward inner site area.[3]

The attributes, which are sufficiently numerous within testing squares, are related to the types of raw material. The mound spring sites are characterised by different proportions of four common types of raw material; each site with its own peculiar combination of stone types. These proportions are reflected within each sampling square (with the exception of those where the number of artefacts is significantly below 100 objects; however, even squares containing 30 objects often retain this pattern characteristic for the site, eg. site D).

The four common types of raw material are quartzite, quartz, chert and silcrete. Other materials, such as mudstone, white quartz, porcellinite, flint and opal, constitute only a small proportion of raw material ranging from 0.32 to 1.98% of the total material on the sites.

The advantage of using proportions of the raw material to test the similarity of area units is that about 99% of objects are clearly classified to one, and only one, category. Furthermore, such a classification is not related to the archaeological typology of stone artefacts. The significance of correspondence analysis is that sampling units cluster in separate groups, each representing one of the eight sites included in this study.

This even distribution of raw material on the sites is not coincidental and it reflects the use of the sites. The origin of this evenness can be explain by the following scenario. In the total span of the site's intermittent occupation many camping episodes took place. Every camping episode entailed a range of different activities generating a discard of stone artefacts. The episodes representing each activity occurred several hundred or even several thousand times on each site. Because every subsequent camping episode was shifted around in relation to the preceding one and because the activity episodes were scattered

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[3]. It is worth noting that evidence for the majority of excavated sites is derived largely if not exclusively from inner site area; a periphery being seldom mentioned let alone examined.

differently in the site-core area, every square metre of inner-campsite has an equal chance of receiving a fair portion of refuse generated by all kinds of activities. Subsequently, each square within the site's high density area reflects this location-specific representation of discard and by inference - activities.

The evenness is a product of the large number of objects and the extensive shifting of activity areas. These two factors can be accounted for by many camping episodes. These episodes can be inferred from the sheer number of artefacts on the sites. The distribution of fireplace debris recorded on site B provides other supportive evidence for the intensive occupation of the mound spring campsites (Fig. 10, p.109).

CHAPTER VII

ANALYSIS: DESIGN AND DIRECTION

'in science of natural history [...] nearly all theoretical claims are arguments about relative frequencies, not statements about exclusivity.'

Stephen Jay Gould 1987:37

1. Introduction

The term analysis, derived from the Greek, means loosening or **undoing**. An analysis can simply be understood as the process of dismantling an object or structure in order to learn about it by examining its components and the way in which these components are assembled. It is assumed, and often proved, that smaller building blocks contribute to a specific quality of the whole object. Analysis also refers to a search for causes from their effects.

This definition is particularly appropriate since the division of archaeological material is a crucial part of the analytical design in my research. The partitioning also seeks to link observable effects (archaeological attributes) with their causes. In this chapter I will discuss how such an analysis is designed and developed in this project.

An analysis, as a process of exploring end learning, requires that the inherent order of nature (eg. archaeological record) is respected. It is necessary to give nature a chance to talk back, so that the pattern comes from the archaeological records and not the researcher's preconcieved ideas (Binford 1986, 1991). On the other hand the analysis requires active involvement by a scientist to convert empirical observations into data (Binford 1986; Aldenderfer 1987). This process can only be selective and based on existing knowledge and hypotheses. Therefore the crucial step of analysis is to select what aspect of the natural order will be focused upon and consequently, how the body of empirical observation is disassembled.

2. Focusing analysis on the stone artefacts

In selecting an aspect of nature (the archaeological record) in this study I focused upon variation in the content of stone assemblages and its immediate causes. Accordingly I refrain here from discussing whether archaeological records manifest a symbolic meaning and therefore signify cultural or ethnic entities. I simply assume that the stone artefacts dealt with in this project, can be broadly described as hardware and must be placed in the context of tangible reality as it is expressed by Gellner (1982:117):

> 'there are extensive aspects of human life, alas including those that seem essential for our survival, where the actual sequence of events is determined not merely by free play of some underlying core mechanism (if indeed it exists at all), but by the blind constraints and shortages and competitions and pressures of the real extraneous environment.'

It appears that the acquisition of knowledge in prehistory increases mainly through studies targeting economic and environmental aspects of archaeological records rather than their stylistic, symbolic, or ethnic significance.[1] The following example illustrates that stone artefacts taken as hardware, which correlates with the real world and its constraints, opens up a fruitful and testable field of discovery.

Once an elaborate typology of Palaeolithic stone artefacts was developed and adopted widely in Europe (eg. Bordes 1961; Bordes and Sonneville-Bordes 1970), it became a standard procedure to group stone assemblages in accordance with artefact types and their relative frequencies. This unified system of classification provided the means for comparison across geographical regions and time horizons. It also furnished a basis for quantification in Palaeolithic archaeology. By contrast with the Mousterian, Upper and Final Palaeolithic assemblages show a

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[1]. 'I do not doubt for the moment that microtraditions (sensu Close, Sackett) existed in the fabrication of stone artefacts, but I think that the Late Pleistocene archaeological record is so coarse-grained that the probability of identifying them is virtually nil' (Clark 1989:33).

strong tendency to regional groupings. When subjected to this classification, nearly all assemblages can be neatly grouped into regional clusters with limited time and space boundaries (Clarke 1968). Such groupings, often referred to as archaeological cultures (Clarke 1968; Dolukhanov et al. 1980; Dolukhanov 1982; Otte 1990; Otte and Keeley 1990), inevitably lead to the supposition that Palaeolithic societies were not substantially different from the hunter-gatherers encountered by past and modern ethnographers.

Although Palaeolithic archaeology did not restrict itself to the delineation of archaeological cultures, in many circles it was a common research target, and interpretation of such cultures was attempted in a way similar to the history of nations or ethnic groups with invasions, changes of boundaries, migrations and acculturation (eg. Otte and Keeley 1990; also critique by Clark and Lindly 1991).

As a part of my research into cultural diversity in the Central European Palaeolithic (Florek 1983), I attempted to explore the relationship between basic types of stone tools represented by different assemblages, cultural groupings and environments. I selected only two, the most numerous types of tools - burins and scrapers. The different proportions of these two classes of implement is a significant statistical feature in archaeological cultural groupings. However, in previous studies these implements were given limited attention because they have a largely uniform morphology. Unlike diagnostic points and backed blades, scrapers and burins show little inclination to change in time and across geographical regions.

Following various experimental, use-wear and faunal association studies, I adopted a hypothesis that burins were predominantly used for working bone material, while scrapers were used for wood and hide. This hypothesis was tested against environmental evidence. Burins, supposedly designed for working with bone material, displayed a very strong and consistent correlation with the semi-glacial environment where trees were extremely rare and where animal bones provided the most desirable substitute for wood. In climatic conditions with cold winters, including both semi-glacial and temperate climates, the demand for hide can be assumed to be constant, and the increase in the relative abundance of scrapers may reflect the availability of wood.

Assemblages representing different burin/scraper proportions were plotted on a series of maps symbolising different chronological horizons and showing changes across different environmental regions. What emerged was a clear association between assemblages (and cultures) rich in scrapers and temperate forest environments; assemblages (and cultures) rich in burins are associated with open tundra environments. Burin-rich assemblages are also associated with the constant use of tusk, antlers, and bone from which various implements were made. The decrease of burins in time seems to be related to changes from glacial to interglacial conditions and finally to the warm Atlantic temperature when the proportion of burins shrank to a minute component. Clusters (cultures) located on the ecological boundary show high inter-assemblage variability in the relative proportions of burins and scrapers. This can be explained as a seasonally-varied exploitation of different environmental zones, rather than as a capricious departure from the cultural standard.

This analysis aimed to demonstrate that archaeological cultures (no matter what social entities they may represent) can be seen as technological (or subsistence) systems, responsive to environmental changes, and generating practical solutions in the interface between tools and resources. Such systems may be understood as specific variants of material cultures oriented towards the exploitation of particular environments, rather than purely spatio-temporal groupings defined by a set of abstract attributes and presumably representing separate ethnic entities.

By adopting this utilitarian and materialistic approach I shifted my interest from the possible symbolic or ethnic reference of archaeological records to the immediate causes of variability. Such direct causes refer to human activities such as flaking stone, using implements and discarding by-products and worn out tools. It does not deny that other aspects of variation such as gender, social and ethnic influences may be present in archaeological patterns but it insists that the pattern is produced primarily by human action (combined with formation process influenced by the forces of nature). In practice however, recognition of human activity as an underlying cause of variation often renders other explanations needless if not unwarranted. Above all the immediate causes of variation place emphasis on a different level of the archaeological record and its origin other than 'cultural' or ethnic considerations. In short, I argue that archaeological records are best explained by human activities patterned in acordance with the detectable constraints of environment and technological means.

In adopting such a position in this project I was led to ask: How have the stone artefacts come into existence ? The best theory that I can offer is that the stone artefacts were produced by a reduction process (eg. flaking) and many were even further reduced through usage and use-related maintenance (eg. edge damaging, repetitive resharpening, grinding, breaking). If the stone artefacts originated through reduction, the obvious logical step in their analysis is to measure size/weight. Such an approach instantly places the archaeological records in two complementary contexts: a) supply and properties of raw material, and b) demand for specific hardware generated by a subsistence system.

3. Selecting and dividing empirical observations

A common path of analysis is that in the first stage 'information is parcelled up by perceptual choice into packages' (De Bono 1990:54). In the second stage these packages are subjected to logical reasoning and/or run through highly efficient mathematical processing techniques. These techniques, like a food blender, can process anything, but not everything is edible. So, analysis depends largely on how the body of information is divided and far less on the data processing techniques. In this project I commit more attention to re-parcelling the body of information and to re-considering what goes into each package.

In partitioning the body of archaeological material I adopted three guiding hypotheses: a) the morphology provides immediate clues to the origin of stone artefacts; b) presence or absence of secondary modification of artefacts (retouch) furnishes the basic distinction between by-product/product and expedient/curated objects; c) position and extent of secondary modification (retouch, edge damage) often testifies to the object's usage and its intensity.

According to these hypotheses I divided artefacts into flakes and retouched objects - tools. Flakes were then size-graded into seven groups, while tools were further divided into eight specific groups, corresponding with both archaeological tradition and ethno-historical classification (Aiston 1920-40; Horne and Aiston 1924; Cane 1984, 1988): core, hammerstone, backed blade, scraper, tula, point, retouched flake, and grinding stone.

Reduction, its kind and extent, reflects human activities in the most immediate manner. It also provides strong clues into external constraints such as lack or abundance of supply; into demands such as distant transportation of materials or selection of stone for different tools; and choice of technological solutions such as intensity and spatial scheduling of reduction process.

The attributes that provide the most useful measurement of such divided material are counts, weights and mean weights of stone artefacts. Although I measured, in addition, other attributes (eg. length, width, thickness) of individual objects in selected groups of artefacts (eg. scrapers and retouched flakes), this study departs from more conventional methods of stone assemblage analysis. This departure is most radical in a) size-grading as the measure of reduction process; b) shifting from individual artefact to group of objects, and; c) in focusing on the reduction process as a powerful expression of economic constraints operating in one vital field of the past subsistence system.

4. Comments

This study was well advanced (eg. Florek 1987) when a number of widely circulated publications described the analysis in which the size-grading of flaking debris played the central role (Ahler 1989a, 1989b). Stanley Ahler, who developed this method, refers to it as the mass or aggregate analysis of flaking debris. He developed it by applying the size-grading technique to the concept of recognition of reduction sequence from flaking debris set forth by Newcomer (1971).

Aggregate analysis was applied primarily to experimental flaking and debris pattern of different reduction sequences. The quantified data derived from experimental flaking was scrupulously entered into a data base developed over the last 15 years (Ahler 1989b). With the reference provided by a large body of experimental data the aggregate analysis is capable of distinguishing reduction sequences or their stages in single episodes and mixed archaeological materials. Because experimental replication focused on several reduction sequences evidenced in North American archaeology, the flaking sequence recognition through aggregate analysis is currently limited to the specific region defined by particular tool types such as projectile point, biface, and core.

I developed a similar analytical solution based on the size-grading of flaking debris in response to the vast quantity of material collected from the mound spring sites. By 1987 I had the recording and analytical structure in place, however I had not fully explored the potential of this technique. Unlike several North American projects which focused primarily on the isolated reduction sequences and experimental data (eg. Stahle and Dunn 1982; Magne and Pokotylo 1981; Magne 1989) I applied size-grading and weighing techniques to the mixed archaeological material recovered from habitation sites where discrete units resulting from single reduction processes are either absent or impossible to recover. This approach is much closer to the studies where the reduction process may be recognised without identifying specific reduction sequences (eg. Behm 1983).

Because of the absence of experimental data the analysis developed in this study focuses on the relative degree of reduction (eg. flaking, recycling and tool maintenance) within different assemblages and raw material types. It also explores the relative intensity of usage by measuring degrees of secondary reduction - retouch. Effectively this analytical approach is framed within time and energy budget (Torrence 1983, 1989b) and the concept of curated and expedient technologies (Binford 1977, 1979). Although the method of analysis furnishes a fine resolution of the mound spring sites' variability (chapter VIII), I think that its full potential is yet to be realised. The obvious direction of developement is through experimental studies of the local Australian reduction sequences.

5. Organising the data base

A data base system allows for the recording of 180 attributes for each sampling unit (1m^2) of the assemblage. These attributes are amalgamated in sub-total and total categories, providing an extra 31 secondary attributes.

All attributes are counts and weights (in grammes to one decimal place). These quantitative attributes are measured for 17 classes of objects within 5 classes of raw material. Two extra classes of objects are recorded as counts only within 5 classes of raw material ($(17 \times 5) \times 2 + 2 \times 5 = 180$).

The 17 classes of objects are: seven groups of plain flakes of different size, core, hammerstone, backed blade, scraper, tula, point, retouched flake, ground tool, shatter generated by mechanical stress (during flaking and/or other stone-related activities) and, shatter generated by thermal stress. The two extra classes are: cortical flake and blade.

There is no common agreement on the classification of stone tools, terminology, and their possible functional meaning. This lack of consensus appeared clearly during the conference dedicated to stone tool technology and analysis at the University of New England in 1988. Most categories in the above classification are drawn from the ethno-historical and ethnoarchaeological recording of stone tools in the arid Australia (especially Aiston 1920-40, 1928; Horne and Aiston 1924; Cane 1984, 1988). It should be noticed that because of the general level of this classification, the same categories of artefacts are commonly referred to in most archaeological studies (eg. Campbell and Noone 1943; McCarthy et al. 1946; Mitchell 1949; Campbell and Edvards 1966; Mulvaney 1969, 1977; Morwood 1981; Kamminga 1982; Schrire 1982; Cane 1984; Allen and Berton 1989).

All 19 categories of artefacts are recorded separately for 5 different types of raw material: quartzite, quartz, chert, silcrete and other (the last consists of only minute components of raw material, less than 2%, and is commonly represented by mudstone, indurated sandstone, fossilised wood, and opal).

114 pairs of attributes (count/weight), including amalgamated categories, provide easily obtained mean weight for the objects in each class (excluding cortical flakes and blades: two out of 31 amalgamated categories) (17x5) + 29 = 114).

While single sampling units allow for easy comparison of the spatial distribution of attributes within a site and between sites, all unit samples for each site were further amalgamated to provide one set of comparable data demonstrated to be representative of a particular assemblage (chapter IV).

In practice, not all 180 primary attributes are present within the assemblage samples. Lack of an attribute, however, is understood here as evidence in its own right. Table 9 (p.169) shows the number of primary attributes recorded for each assemblage.

6. Preliminary analysis

In practice, the data base permits manipulation of about 100 positively recorded attributes (for classes where the count is larger than 0). Such an organisation of data is ideally suited to multivariate analysis (Wright 1989). However, before such an analysis is undertaken, I wish to attempt a preliminary

Table 9: number of attributes recorded for each site

site	No of attributes recorded	No of sampling units ($1m^2$)
A	116	16
B	122	53
C	86	86
D	110	275
E	120	33
G	122	22
H	120	50
ST	94	8

exploration of the data in order to illustrate, by several examples, that theoretical requirements can be met by this system of analysis and meaningful results procured. For clarity, only one or two components (attributes) are used at a time to demonstrate a specific aspect of the sites' variability.

The strong data structure permits such exploration by the simplest means, such as tabulation and percentages, which do not reinforce or amplify existing patterns (Whallon 1987). Such preliminary exploration has a triple purpose. Firstly, it shows that the theoretical framework of analysis developed in this project is applicable and that it is capable of producing meaningful results. Secondly, it demonstrates an ability to bridge two levels of archaeological evidence, artefact and assemblage. Thirdly, it establishes a general direction for the more elaborate and complex investigation of information parcelled up for this study.

Case 1.

It has been recognised by various experimental and archaeological studies that flaking of many different technological variants results in similar flake-size structure. However, elaborate core preparation tends to produce more small flakes, while specific blade technology results in a large quantity of standardised medium-sized products (eg. Schild 1980;

Johnson and Morrow 1987; Schick 1987). Therefore, flaking can be inferred from archaeological material not only by time-consuming refitting of stone artefacts, but also by the analysis of the size structure of flakes (Florek 1987). This method is especially useful when knapping products are not preserved within neat clusters but are widely dispersed and superimposed by many subsequent uses of the site and by post-depositional disturbances. There are many factors involved in distorting the original structure of assemblages. For instance, a primary site of activity can favour preservation of larger objects while smaller ones are wiped out by natural agents. Similarly, a secondary deposition site can favour the accumulation of smaller objects, while the larger ones are left behind and possibly even incorporated into entirely different sedimentation units (Schick 1986).

The preliminary analysis revealed that the assemblages included in this study represent two different modes of flake-size structure. In one, the smallest flakes are most abundant; in the other, the medium-sized flakes are dominant. However, two assemblages only (ST and G) are decisively dominated by small flakes, while two others (A and D), are clearly dominated by medium-sized flakes (Table 10, p.171).

It can be suggested that the assemblages G and ST represent sites where extensive flaking took place. Other assemblages can be assumed to represent an average tendency with medium flakes being slightly more numerous than small-size flakes. This suggest that, for whatever reason, intensive flaking was preferably conducted in off-site context.

Case 2.

Stone cores are recognised in the ethno-archaeological and prehistoric context aş the source of flakes (regardless of whether a core is subsequently used as a tool or not). Likewise, hammerstones are recognised as flaking tools (Tindale 1965, 1985; Jones and White 1988; Binford and O'Connell 1984; Cane 1984). It can be expected that flaking refuse is associated with numerous

Table 10: relative percentage frequencies of small and medium size flakes

site	small flakes up to 1.5 cm %	medium flakes 1.6-3.0 cm %	N
A	43	57	1711
B	51	49	8958
C	48	52	2059
D	43	57	4073
E	48	52	7427
G	58	42	14407
H	52	48	8789
ST	68	32	2145

hammerstones. Table 11 (p.172) illustrates the relation between cores and hammerstones. While the above assumption has been proved correct for the assemblage G, it has not predicted the overall tool structure in the assemblage ST where hammerstones are absent (the absolute absence can be explained by the small sample, but it probably reflects the minute amount of hammerstones in this assemblage). The glaring contradiction between the large proportion of smallest flakes (Table 10) and absence (or tiny component) of primary flaking tools (Table 11, p. 172) represents a puzzling case which needs to be explained.

Other assemblages, again, may demonstrate average tendency, showing that with limited flaking performed on site the core/hammer ratio is expected to be about 19:1.

Case 3.

Site ST is located within an alluvial plain, far from sources of any stone material suitable for flaking. The only stone in the vicinity of this site is calcrete from the mound springs. Lumps of this stone were used as 'cooking stones', despite the fact that they split easily and crumble in the heat. All other stones used on the site ST were transported from as far as 10 km away. It can be expected that all stone objects would have been reduced in size by more extensive flaking and by the recycling of any items suitable for different use. This

Table 11: relative percentage frequencies of cores and hammerstones

site	cores %	hammers %	No
A	93.5	6.4	62
B	97.7	2.2	135
C	93.9	6.0	33
D	93.8	6.1	113
E	96.2	3.8	108
G	79.2	20.8	125
H	94.1	5.8	120
ST	100.0	0	20

assumption is affirmed by the small mean weight of stone flakes divided into four different types of raw material (Table 12).

Table 12: average weight of flakes

site	average weight in grammes QT	Q	C	S	N
A	5.5	2.8	1.4	2.9	2021
B	3.3	1.5	0.8	1.6	9699
C	9.4	1.0	1.4	3.5	2412
D	6.8	1.5	0.7	2.5	5305
E	3.4	1.4	0.8	2.2	8662
G	2.8	1.1	0.5	1.3	16280
H	2.7	1.2	0.6	1.7	9467
ST	1.6	1.0	0.4	1.2	2297

QT-quartzite; Q-quartz; C-chert; S-silcrete

In light of these data, two factors need to be considered. One is that hammerstones were possibly recycled and may eventually have been flaked themselves, or may have been used as 'cooking stones.' In either case, they can be re-utilised beyond recognition. The second factor to consider is that site ST does not represent much primary knapping but an exceptionally extensive reduction of artefacts due to the distant sources of raw materials. This reduction would include curation of tools and intensive resharpening.

Case 4

It has been observed that tools make up only a small fraction of stone artefacts on archaeological sites. In my sample this portion makes up less than 5% (Table 13). On the sites where significant amounts of flaking took place, the percentage of tools is the smallest, as is demonstrated by site G and ST.

Table 13: percentage of tools* per assemblage

Site	% of tools	No of all artefacts
A	4.8	2620
B	4.6	11677
C	3.7	2655
D	3.9	8402
E	3.8	10859
G	2.9	18483
H	4.4	11019
ST	3.4	2664

*including retouched flakes

Because tools represent such a small proportion of assemblages, inferences based on their relative frequencies must be approached with caution. The safest way of re-packaging this group of artefacts without splitting it into too small parcels is to divide it into two groups: more formalised tools and retouched flakes. The relative proportions between these two groups (Table 14, p.174) reveal that only assemblage B is characterised by a slight majority of tools in relation to retouched flakes. In contrast, assemblage C shows an overwhelming majority of retouched flakes. This is a clear reflection of the fact that site C is located near a silcrete outcrop. An abundant supply of raw material seems to induce an expedient use of artefacts.

This proportion observed in other assemblages suggest the average tendency where retouched flakes outnumber more formalised tools 1.4 times.

Table 14: relative percentage frequencies of tools and retouched flakes

site	tools %	retouched flakes %	No
A	48.0	52.0	121
B	51.1	48.9	529
C	21.7	78.3	97
D	37.1	62.9	286
E	33.6	66.4	411
G	40.4	59.6	486
H	41.0	59.0	476
ST	46.5	53.5	84

This observation leads to another supposition. If retouched flakes can provide at least a partial substitute for other tools, it can be assumed that retouched flakes, or some of them, can be developed through use and rejuvenation into some kind of formal tool.

Case 5

Studies concerned with the function of stone tools suggest that retouched flakes and scrapers are usually associated with woodwork (Gould 1977; Kamminga 1982; Hayden 1978, 1979a; Cane 1984, 1988; Donahue 1988; Witter pers. comm. 1991). Retouch present along the edges of scrapers, and retouched flakes can be seen as a result of resharpening and probably edge-angle maintenance (Willmsen 1974; Gould *et al*. 1971) rather than being a part of a tool design. A possible scenario is that plain flakes are used first. Some of them are discarded when proved unfit or blunted; some of them however, are resharpened, and therefore transformed into a category of retouched flakes. The same selection process continues, and some retouched flakes are discarded while others are further trimmed into the form of scrapers (compare Ranere 1975; Dibble 1984, 1987).

If retouched flakes are the second generation of woodwork tools and have the potential to be transformed by more formalised and regular retouch into scrapers, then retouched flakes should be generally larger than scrapers. The measured samples of quartzite retouched flakes and scrapers are presented in Table 15.[2]

Table 15: average weight of quartzite retouched flakes and scrapers (g)

site	complete specimens ret. flakes	complete specimens scrapers	broken specimens ret. flakes	broken specimens scrapers	No
D	45.4	38.8	32.0	10.6	142
E	19.5	19.2	11.7	10.6	207
G	29.5	14.4	19.1	13.9	138

Such an analysis opens the door to the potential quantification of reduction which took place in transforming retouched flakes into scrapers. It also permits further inquiry into the economy of raw materials and the utilisation of tools. Table 16 (p.176) illustrates the proportions of retouched flakes and scrapers. It is apparent that, where there is a plentiful supply of raw material, the discard rate of retouched flakes is higher (assemblages C and G). A high proportion of scrapers reflects more intense use of flakes and probably the subsequent transformation of flakes into scrapers. In the other words it suggests a degree of curation.

The last Table (17) shows the relative proportions of retouched flakes on the one hand, and scrapers and tulas on the other. Retouched flakes can be seen as an indication of the expedient use of tools, while scrapers and tulas indicate a more conservation-oriented approach to the implements.

The three assemblages showing a high proportion of scrapers and tulas are all distant from sufficient raw material sources. Site ST is far away from any source of stone for flaking. Sites

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[2]. Only samples from three sites D, E and G contain the number of quartzite scrapers sufficient for statistical observation.

Table 16: relative proportions between retouched flakes and scrapers (all types of raw material)

site	retouched flakes %	scrapers %	No
A	56.2	43.7	112
B	64.4	35.5	402
C	88.8	11.1	45
D	64.9	35.0	277
E	72.2	27.7	378
G	75.1	24.8	386
H	71.3	28.7	394
ST	69.2	30.7	65

Table 17: relative proportions between retouched flakes and scrapers/tulas

site	retouched flakes %	scrapers/tulas %	N
A	54.3	45.6	116
B	61.9	38.0	418
C	86.9	13.0	46
D	63.8	36.1	282
E	70.9	29.1	385
G	69.3	30.6	418
H	67.7	32.2	415
ST	59.2	40.7	76

A and B are close to sources of quartz and poor quality quartzite, but material such as chert and silcrete, the most suitable and most commonly used for scrapers and tulas, needs to be transported from unknown distant sources. As expected site C shows a low degree of curation expressed by small proportion of scrapers/tulas against retouched flakes.

7. Conclusions

The above examples by no means exhaust the analytical potential of the data. In addition, these examples are not expected to stand on their own but must be read in conjunction with other data. They will also be further analysed in a multivariate mode.

Nonetheless, the single variables presented here demonstrate both how the evidence is mustered, and how the analysis is approached, based on the assumption of human rationality, the reliance on relative frequencies, and the search for a tangible explanation of data structure. These components are blended together in the framework of meaningful data. In addition, the above examples show that explanation is drawn from the realm of archaeological (even if not quantified) observations, and that these observations are subject to testing and re-analysis; explanation is not sought beyond the sphere of observations.

While the final interpretation of archaeological research must attempt to link data concerning material objects to human behaviour (framed within the social and cultural reality of the past), analytical explanation should remain grounded within an observable, recorded and testable body of evidence.

For this reason I take special precautions in moving from the interpretation of site diversity to further generalisations, such as chronological or cultural difference between the sites. What seems clear from this preliminary screening of data is that variability of assemblages can be best accounted for functionally, that is by the different proportions of activities, intensity and materials involved. If this is true, both chronological and cultural explanations are not necessary, or more precisely they are different parameters which can not be directly inferred from the sites' variability alone. In other words, diversity of assemblages is not enough, and also not necessary, to demonstrate differences of culture. As was illustrated above, different archaeological cultures may converge in response to environmental constraints. The problem arising in this study is that different assemblages seem to be associated with the same subsistence (if not tribal) system. This unusual case will be further explored below, but the immediate goal is to provide detailed evidence of sites' diversity and to explain it within the framework of different activities, technological modes, availability and use of raw materials. This goal is pursued in the next chapter.

CHAPTER VIII

VARIABILITY OF ASSEMBLAGES: STATISTICAL ANALYSIS AND EXPLANATION

1. Introduction

In this chapter several aspects of the inter-assemblage variability are analysed. They are grouped into three major categories: 1) lithic raw materials and debitage; 2) association between raw materials and tools, and; 3) relative frequency of tools. Such a division, though arbitrary, serves to facilitate some order of description. In reality many sub-sets of data drawn for specific analysis criss-cross these artificial boundaries. For example, some features of stone technology are integrated into different aspects of analysis.

2. Rationale

The analysis attempted here seeks to link observed patterns with a human factor. The rationale for such a linkage is mainly based on the fact that human activity is not driven by supply but rather by demands mediated by knowledge of resources and technological competence. In this context, an artefact can be defined by goal, task, and performance. Morphological and physical properties of an artefact can reveal some tendencies in human behaviour when analysed against other artefacts (assumed average tendency) and environmental background.

The human factor can be seen through a tendency to maximise return and minimise cost (energy, labour, time). This is known from our common experience as well as basic rules of economy. For example, a core tends to be smaller when discarded further from the source of lithic raw material (eg. Byrne 1980; Hiscock 1984). Similarly, material that is labor intensive to procure and work with tends to be used in curated tools (Gould 1978).

Most importantly, the human factor manifests itself by the fact that categories of tools present in an assemblage are not dependent upon the availability of specific lithic raw material near the site but rather by the demand for specific hardware. For example, tula adzes are preferably made from chert and silcrete

(Fig. 39, p.211) but the assemblages in relative proximity to the source of these materials may contain only moderate proportions of these tools (eg. site H).

The same point can be seen from a different perspective, when the most preferred material is substituted by another type of stone. For instance, silcrete and quartz are the most favoured materials for backed blades (Fig. 39, p.211) but on site G, away from the source of these raw materials, about two thirds of the blades are made of local quartzite.

These examples suggest that tools are generated by demand and are job-specific. A large portion of an assemblage seems to represent a compromise between demand and supply, especially in the area of instant, short-lived tools such as retouched flakes.[1] Tools made from non-local materials clearly demonstrate that such compromise was compensated for by anticipation and planning.

However, inferences drawn here will be restricted to the direct links between archaeological material and the human activity immediately involved in technological solutions. There is no attempt made to describe an emic aspect of the past social system. Selected solutions are defined on the one hand by the physical property of artefacts and their relative frequencies; and on the other by goal, task, and performance. Most of the results are self-explanatory and concluding inferences only spell out what has been done by the site's inhabitants; there is no need to refer to human thoughts and reflections.

The only guiding assumption is that in the field of subsistence and use of hardware people often seek rational solutions. Such a rational tendency can be condensed into a rule of economising. When the cost of procurement is high, use tends to be intensive (eg. economising through curation and size reduction); when the supply is in abundance, economising may prove to be too costly in terms of time and labour. Economising also involves making good use of local material, transporting necessary goods and scheduling activities in space and time. I am reluctant to label this tendency as a drive to minimise cost

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[1]. With one exception (site A), the majority of retouched flakes are always made from the most common, locally available raw material (fig. 42).

and maximise return, because many observed patterns entail far more complex relationships than can be gauged exclusively by such a crude device. However, understanding the complexity of subsistence 'economy' and its reflection on the habitation sites we can accept that such 'optimal' solutions determined a large portion of archaeological patterning.

3. Methods of analyses

The analysis developed in this project attempts a major shift from quantifying and recording the attributes of individual objects to a method akin to mass analysis. The mass analysis cannot be employed here in its full format due to lack of sufficient quantification of experimental data (Ahler 1989a, 1989b; see chapter VII for discussion). However, my analysis relies on the same principles. Stone knapping is a reductive technology which imposes predictive restrictions on the size of a product; and variation in force and its placement results in a corresponding variation in size and shape of flakes (Ahler 1989a:89). Therefore the size grading of debitage is the first practical step towards measuring reduction processes and (with appropriate experimental data) discerning different knapping techniques and their stages. Counts and average weights of flakes in every size grade provide a good reflection of the knapping process. This is especially useful in analysing large samples of debitage resulting from many reduction episodes.

Retouched artefacts (tools) are grouped into several broad categories defined by a set of attributes which reflect morphology, technology and macroscopic use-wear. While debitage is a direct result of stone craft, tools were used in crafts involving other materials (eg. wood) and specific tasks (eg. chopping, adzing). The unique, long term ethno-historical observations conducted in the Lake Eyre district provide a nearly complete guide to the traditional use of stone tools (Aiston 1920-40, 1928, 1934; Horne and Aiston 1924). Except for the manufacture of pirri points and use of backed blades there is a comprehensive body of ethnographic data concerning production and application of late Holocene stone tools in the region. This knowledge is supplemented by other observations made in central and northern Australia (eg. Tindale 1941, 1965; Thomson 1964;

Jones and White 1988). More systematic ethno-archaeological studies in Western Desert (eg. Gould 1968, 1977; Gould et al. 1971; Hayden 1977, 1979a; Cane 1984) not only expand our knowledge but provide proof that, though often disputed, the classification of tools is valid in its original economic context and in an emic perception of the relationship between stone tool morphology and its function (Cane 1988).

To most of the archaeological studies, evidence assembled in the Lake Eyre district can provide only a broad ethnographic analogy. In this study the same body of data can serve as a rare example of direct analogy where ethno-history is an immediate extension of the cultural reality focused on in the project. While this analogy is used in a very measured manner it offers a valuable supplement to the archaeological explanation.

While refering to the function of implements I mean not only that specific tool types may have been used to work with different materials (eg. scraper with wood, hammer with stone) and different methods (eg. carving and knapping respectively) but also that they played different roles in the domain of hardware. These roles can be defined by the modes of tool procurement, durability, maintenance, hafting, use, recycling and discard and can be inferred from a tool's morphology, size, degree of modification, use-wear, material, and setting of discard. Such an examination can best be pursued with the group of tools in the assmblage context rather than by analysing single objects in separation. Functional analysis in this broad sense is conducted in this chapter.

The quantified material shows a strong data structure. Many aspects of this structure can be seen in the tables of data. Because the analysis aims to demonstrate many aspects of assemblage variability, the numerous data sub-sets are defined by relatively small and simple sets of variables. For this reason the sub-sets of data can be easily presented by tables and simple diagrams.

Correspondence analysis, which I used extensively for data exploration, proved to be the most practical for many aspects of analysis presented in this chapter. There are three reasons why I have chosen correspondence analysis as my favoured statistical tool.

The strong structure of data used in this study does not require reinforcement by other analytical techniques. A scattergram resulting from correspondence analysis tends to group similar objects (as defined by selected variables) but does not force them into rigid groupings. This provides a picture closer to an intuitive association of similar objects and also it corresponds better with reality where similarities and differences are often a matter of degree. The same applies to the separation of objects where they are placed apart but not put into entirely different boxes.

In correspondence analysis variables are analysed in terms of objects and objects in terms of variables. Therefore variable scores and object scores can be plotted on the same scattergram (Wright 1989). This is a great advantage in visual presentation of results.

However multivariate analysis is also a way to reduce the complexity of data. When I wanted to demonstrate complexity, correspondence analysis is supplemented with or replaced by a series of simple diagrams.

For the same reason, to demonstrate complexity behind the assemblage variation, I conduct a number of separate tests rather than attempting one grand multivariate analysis where many different variables could have been crammed into a single table of data.

4. Raw materials

FREQUENCY

The most obvious variation between the mound spring sites is in different proportions of lithic raw materials. The four types which make up approximately 99% of total material on the sites are quartzite, quartz, chert, and silcrete. Distribution of these materials between the sites is illustrated by the frequency diagram (Fig. 27, p.184). The same set of data has been subjected to correspondence analysis (Fig. 28, p.185). Interpretation of this pattern is relatively straight forward.

On site C, located near a silcrete quarry, local silcrete accounts for over 90% of material. Site G is only several hundred

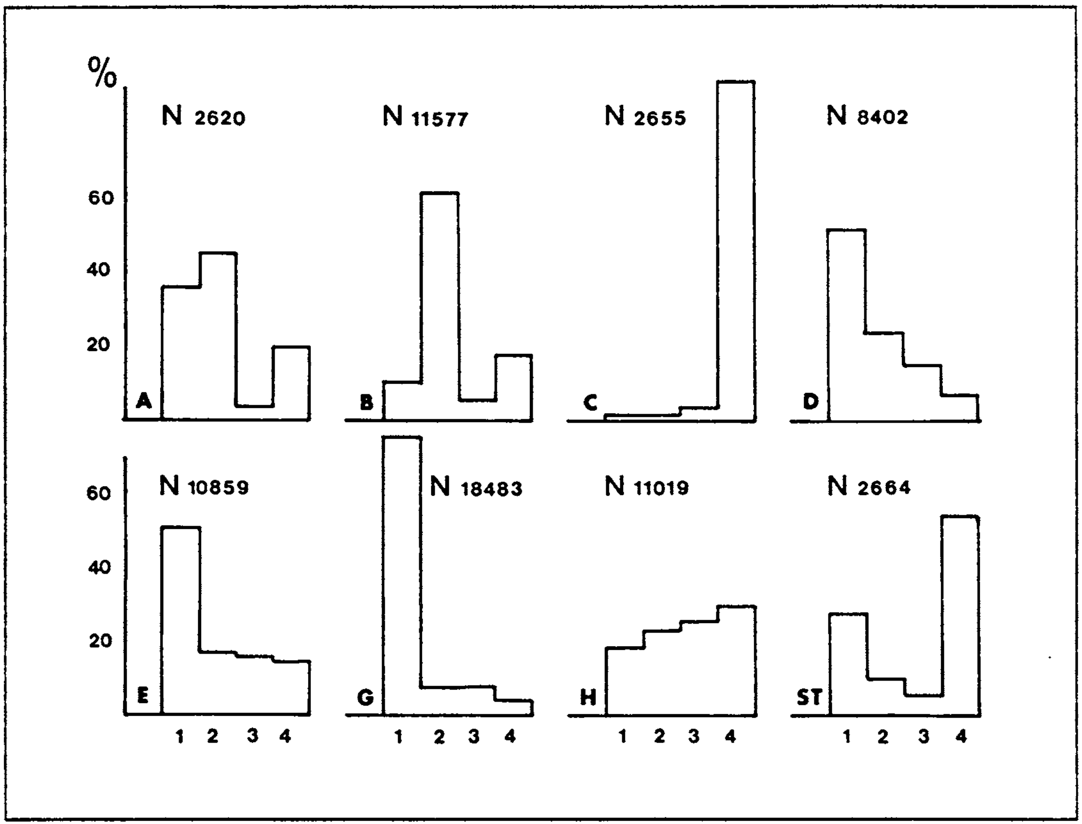

Figure 27. Relative frequency of raw materials within assemblages (1: quartzite; 2: quartz; 3: chert; 4: silcrete).

metres from a quartzite quarry and here quartzite comprises about 75% of lithic material. Located a short distance from the best source of quartz, site B is characterised by above 60% of this material. Sites D and E are in the same area where quartzite seems to be the best locally available material but is not confined to any specific outcrop. On these sites quartzite represents about 50% of lithic material. Site ST is away from any stone suitable for flaking but in the region of numerous silcrete outcrops, and here silcrete make up 55% of material.

Two outstanding cases are sites A and H. Site A is located right at the edge of outcropping conglomerate, a local source of quartz but this material makes only 45% of stone while the second largest portion (35%) is made up by quartzite. There are all types of stone in the vicinity of site H and here the proportion of materials is the most balanced. Silcrete is dominant, making up 30% of material while the least common, quartzite, accounts for nearly 20% of the total.

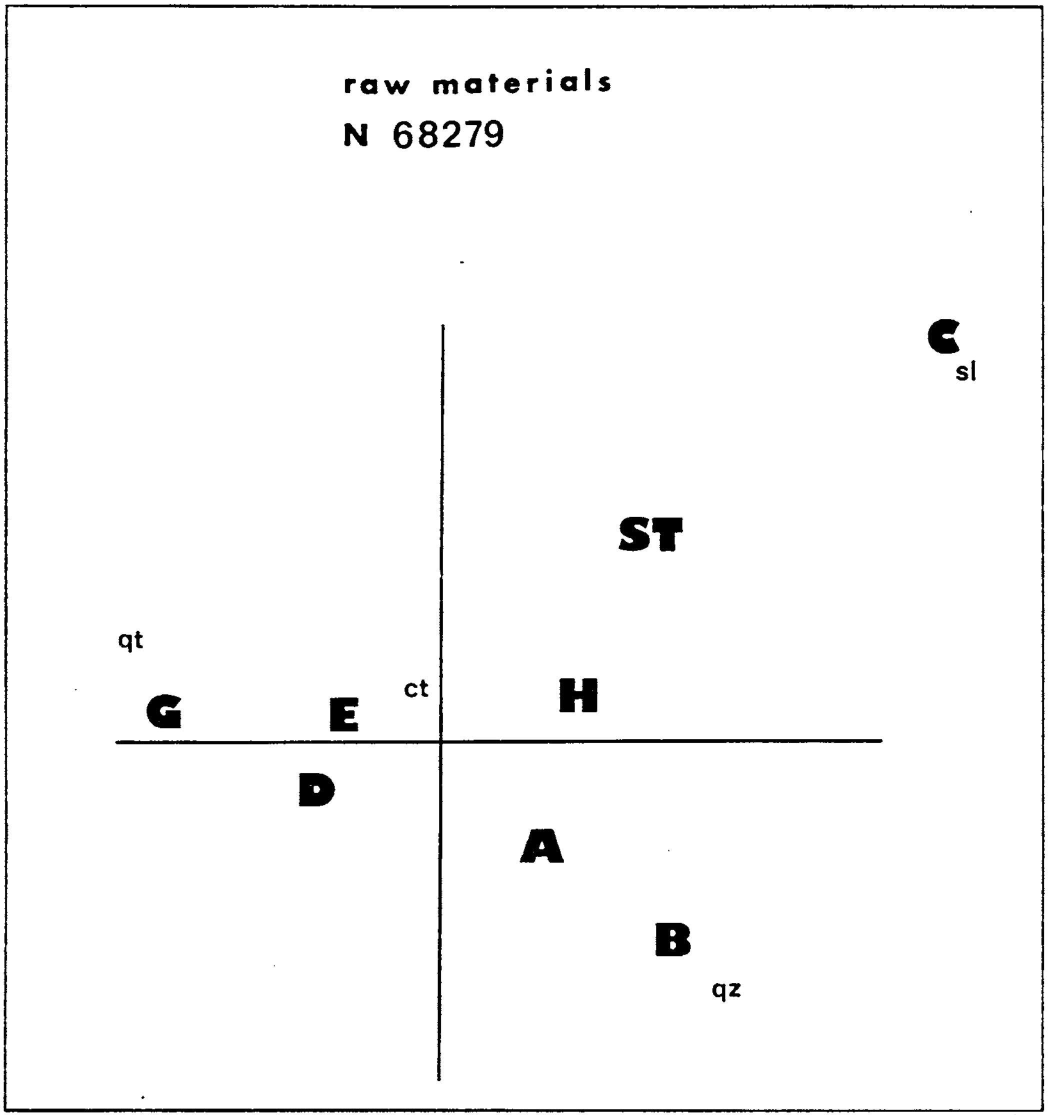

Figure 28. Correspondence analysis showing relationship between raw materials and assemblages (qt: quartzite; qz: quarzt; ct: chert; sl: silcrete).

Another way to look at these differences is to group sites according to the most common raw material. There are three sites C, ST and H where silcrete is most common; the other three G, D and E are dominated by quartzite, and; two remaining sites B and A are dominated by quartz. Apart from the site H, chert constitutes only a small portion of material on the mound spring sites.

This distribution of raw materials provides only a general and somewhat crude picture of variability. Above all it suggests a strong correlation between dominant material on the site and its local availability. Two neighbouring sites A and B demonstrate that the supply of raw material is a strong but not the sole influence on variation. Site A is dominated by quartz (45%) followed closely by quartzite (35%) while silcrete makes about one fifth (20%) of the total. Site B, on the other hand, is dominated by quartz (62%), followed by silcrete (18%), with quartzite accounting for only a small portion (10%) of total. Chert is rare on both sites with only 4% on site A, and 6% on site B (Fig. 27, p.184).

Two other sites D and E located in the same area provide another example, but where variation is far less obvious. Both sites are dominated by quartzite (50%), however on site D it is followed by quartz (24%), chert (15%), and silcrete (8%). On the site E quartz accounts for only 18%, closely followed by chert (16%) and silcrete (15%) (Fig. 27, p.184).

It may seem that the small variation in the proportion of raw materials on sites D and E is insignificant and can be attributed to a random factor rather than to different preferences in the selection of material by the sites' inhabitants. This problem cannot be resolved by a single set of variables presented above. Indeed, in several other crude measures of variability such as proportion of tools, these two assemblages are most similar (Fig. 41, p.214). In reality the variation is far more subtle; for example half of the scrapers on site D are relatively robust and heavy and made from quartzite (mean weight 48.1 g) while half of the scrapers on site E are very small, of thumbnail variety and made from chert (mean weight 2.5 g).

PHYSICAL PROPERTIES

This example brings us to the other aspect of variation in raw materials between the sites. The four types of stone display different physical properties. It would be difficult to escape the conclusion that the stone materials have been selected for their physical property and therefore in consideration of task and performance. The general properties of lithic materials can be summarised as follow.

Quartzite and quartz are the most common materials in the mound spring country, and are very different. Quartzite is easy to find in the form of large pebbles, usually coarse and hard with moderately sharp edges when flaked. It is a material suitable for hammerstones, anvils, large choppers and a variety of large to medium size scrapers. Quartz, on the other hand, can be found in the form of small pebbles, and it is often of glass-like texture which gives flakes with very sharp edges. Quartz is difficult to retouch and repetitively re-sharpen and therefore if there is an alternative stone material available, quartz is rarely used for secondarily modified implements (Dickson 1977:97).[2]

Silcrete is relatively less common in the eastern part and more common in the western part of the study area. This material can be found in the form of very large blocks as well as medium-size to smallish pebbles. It ranges from coarse to smooth, almost chert-like texture. The good quality silcrete must have been quarried, as both cores and flakes suggest that 'blocks' and not 'pebbles' were knapped. Silcrete seems to be most universal; it provides sharp edges, is good for retouching and re-sharpening, and can be made into heavy choppers and crude scrapers but also very small thumb-nail scrapers and tulas. Its good flaking property makes silcrete less suitable for hammerstones and anvils.

Chert can be found on the surface in some areas but is generally of small size and poor quality. Better quality chert must have been brought from elsewhere. Although I know some local sources of chert, they seem not to provide material of good quality and sufficient size. I was informed by 'locals' about chert outcrops(s) located west of Lake Eyre in the Denison Ranges, but could not afford enough time to find it. In any event, in relation to the area of this study such sources can be described as non-local, being between 260 and 50 km away from the sites included in this study.

Chert is a smooth and hard material which flakes well. It can be retouched and re-sharpened, is often used in curated tools such as tula and small scrapers, and is the best material to use on hard wood (compare Gould 1978, 1980).

While quartzite, quartz, and silcrete can be defined as local materials, chert can be generally regarded as an "imported"

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[2]. In my data quartz tools (cores excluded) make up about 10% of tools (mean for eight sites) due to exceptionally high proportion of quartz tools on site B (32%) and A (18%) (Table A4 Appendix).

stone.

Figure 29 shows the mean weight of four types of raw material combined for eight sites. This can be read as a crude expression of average tendency. According to this indicator quartzite may be defined as the material associated with large artefacts; silcrete with medium-size; quartz with small, and; chert with very small. We will see later that in reality there are many variations within this general trend.

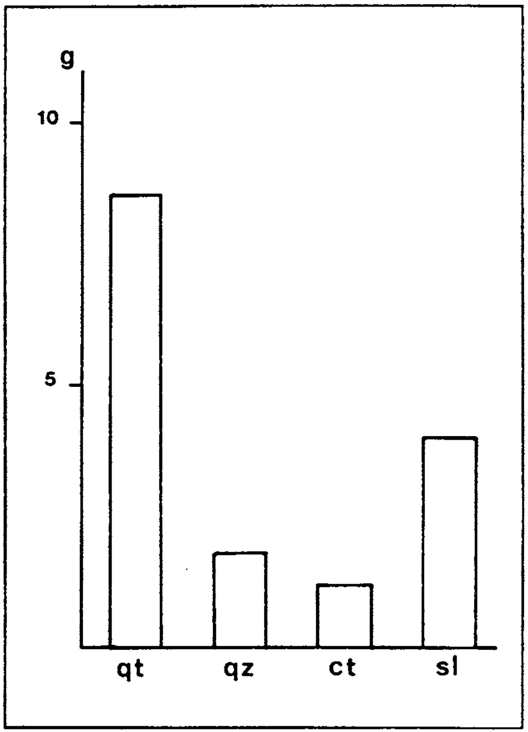

Figure 29. Mean weight of four raw materials for all assemblages combined (qt: quartzite; qz: quartz; ct: chert; sl: silcrete).

TREATMENT

Considering the properties of different raw materials, it can be expected that a specific material will be treated in a particular way, and this will be similar among the sites. However, the stone characteristics must be placed in the context of availability, quality and demand. Consequently the same material can receive somewhat different treatments on different sites. This give extra weight to the argument that inter-site variability may be stimulated but not determined by raw material. This also provides strong evidence that activities carried out on the mound spring sites were different at least in terms of the raw materials used; the forms in which they were brought on to the site, and their subsequent treatment.

The most immediate and crude reflection of the raw material treatment is provided by the degree of reduction, by which I mean flaking, retouching, re-sharpening, recycling, and breakage. In order to analyse the degree of reduction I use three kinds of evidence: 1) mean weight of all artefacts; 2) degree of core reduction, and; 3) raw material reduction reflected by flake-size structure.

Mean weight of artefacts

The mean weight of artefacts indicates the overall degree of reduction. Figure 30 shows the mean weight of all raw materials within eight sites. In Table 18 (p.190) the sites are ranked from small to large mean weight of artefacts.

It is clear that in some cases the size of artefacts can be easily explained in terms of raw material supply; in other cases (note question marks) such an explanation is not possible. The assemblages for which the artefact size cannot be explained by type and distance to raw material suggest that there are other factors influencing the assemblage structure. We will return to this subject in further analysis.

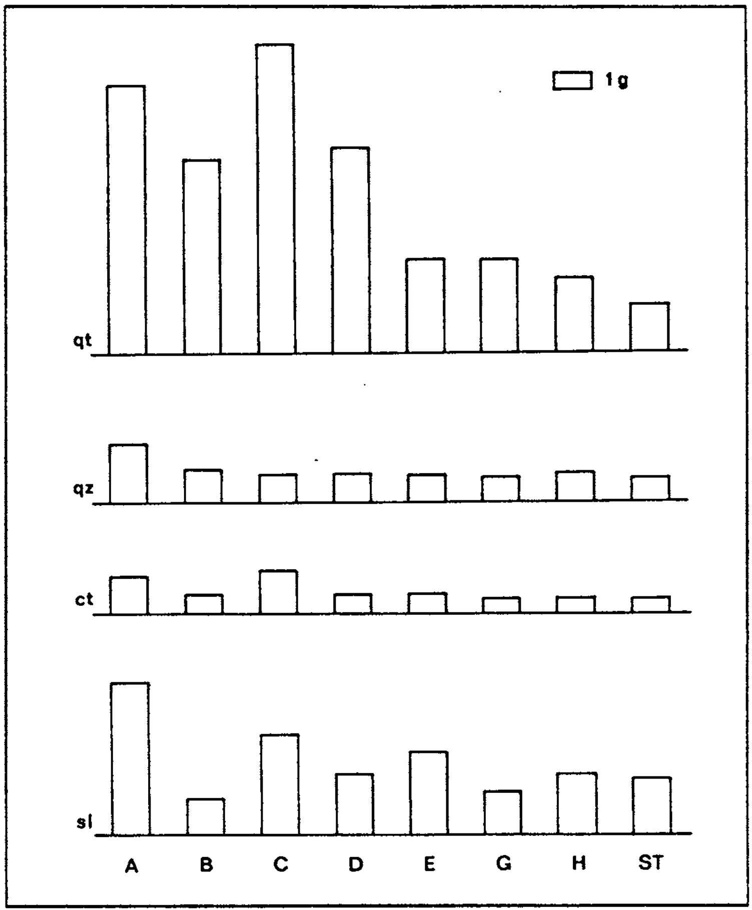

Figure 30. Mean weight of four materials within each assemblage (qt: quartzite; qz: quartz; ct: chert; sl: silcrete).

Degree of core reduction

The foregoing discussion provides a basis for the assumption that raw material was not only brought on to the site in different proportions but also in different forms. These factors have consequently influenced the way the material is treated. Core reduction which can be measured and compared provides some

Table 18: possible causes of artefact sizes

site	mean weight of artefacts (g)	probable cause of reduction (type of material and its source only considered)
H	2.6	dominant chert and quartz (combined), resulting in small size of original raw material
ST	2.6	long distance from the material suitable for flaking
B	2.8	large proportion of quartz supplied from local source, small size of original raw material
E	3.6	(?)
G	4.1	(?)
D	6.5	large proportion of quartzite, large size of original raw material
A	8.1	(?)
C	11.8	(?)

clue to the size of material transported to the sites and to the intensity of flaking. Because cores are not distributed evenly between assemblages and types of raw material, not all materials and sites provide data sufficient for statistical observations.

Core reduction was measured by the area of cortex and/or original surface of stone in relation to the flaked area. Cores were divided into four groups with the cortex area representing: 75% or more, 75% to 50%, 50% to 25%, and less than 25%. Mean weight of cores in each group has then been compared, showing that cores with a large cortex area are heavier while those with a small cortex area are light (Fig. 31, p.191).

In the following analysis two last groups of cores (with 50% or less cortex area) are merged together and are referred to as "well exploited cores".

The size and relative frequency of well exploited cores indicate intensity of core reduction. The size and frequency of

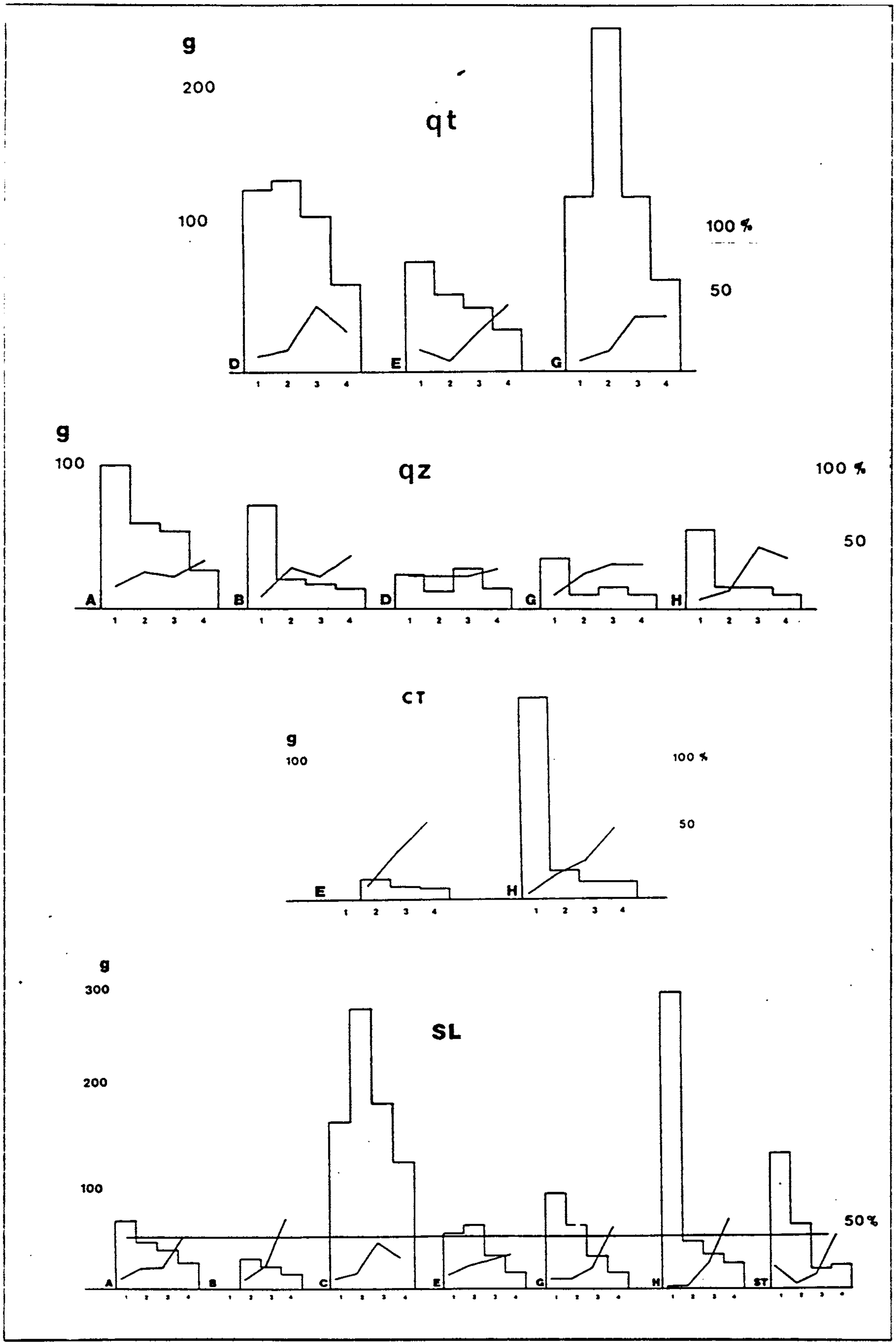

Figure 31. Mean weight (bars: scale in grammes on left) and frequency of cores (lines: scale in % on right), (explanation p.190).

poorly exploited cores suggest the maximum size of blanks/cores which were brought on to the site.

Flake size

Unretouched flakes were divided into seven size-groups.[3] They are: smaller than 1.5 cm; 1.6-3 cm; 3.1-4.5 cm; 4.6-6 cm; 6.1-7.5 cm; 7.6-9 cm, and; larger than 9 cm. Flake size was determined by taking a single, longest dimension (length, width, or thickness). The majority of flakes fell into the first three groups. These three groups of flakes account for 96.6% of all flakes within the sites (mean for eight sites).

Flake size can reveal several aspects of stone technology but primarily it reflects whether flaking or intensive reduction has taken place on the site or whether it was conducted elsewhere. Both archaeological and experimental data suggest that all flaking techniques result in a large quantity of small flakes (eg. Schick 1988; Magne 1989, Ahler 1989a:90).

The relative abundance of small flakes on the site may reflect extensive on-site reduction, by way of primary flaking and/or intensive resharpening and re-using of stone artefacts. The relative abundance of larger flakes suggests that not much primary flaking or intensive reduction were performed on the site (providing that small flakes were not swept from the site by

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[3]. Unretouched flakes consist of complete and broken specimens. I believe now that if complete and broken flakes were analysed separately, better insight into the on-site activities could be gained. However in original analysis these two groups were combined for the following reasons: a) most flakes are broken (60-70% for the samples I measured); b) some flaking techniques result in the large portion of flakes being split (halved) during reduction process (compare comments about quartzite cores, this chapter), and; c) size structure between complete and broken flakes is broadly similar, table below provides example of this relationship:

Complete and broken quartzite flakes, G/30/32: size structure

flakes: %	under 1.5 cm	1.6 cm- 3.0 cm	3.1 cm- 4.5 cm	4.6 cm- 6.0 cm	total
complete:	40.6	36.8	16.5	5.8	187
broken:	56.7	34.2	8.1	0.9	403
complete & broken:	51.5	35.0	10.8	2.5	590

natural agents such as wind or water).

Four scattergrams of correspondence analysis (Fig. 32, p.194) illustrate the relationship between assemblages and flake size within different types of raw material. Although these scattergrams are self-explanatory it is worth noticing that sites G and ST are consistently associated with small flakes in all four types of material. In contrast site D (except for chert) and site A (except for silcrete) are most often associated with large flakes. To make this reading easier I analysed all four materials at once but using only the first two groups of flakes (small up to 1.5cm and medium-size between 1.6cm and 3cm) which together make up 87.2% of all flakes (mean for eight sites), (Fig. 33, p.198; Table A4 in Appendix).

In accordance with several experimental and archaeological studies, the abundance is defined as a 'more or less' relationship between two groups of flakes. For example if the smallest flakes represent 60% and medium-size flakes 40% it indicates that primary flaking or intensive reduction took place on the site. Figure 33 (p.198) shows relative frequency of small and medium-size flakes within four types of raw materials.

Table 19: proportion of small to medium size flakes

site	qt	qz	ct	sl	N
A	-	-	-	-	1689
B	-	+	+	-	8923
C	-	+	-	-	2059
D	-	+	+	-	4069
E	-	+	+	-	7591
G	+	+	+	+	14315
H	-	+	+	-	8734
ST	+	+	+	+	2123

\+ small flakes more numerous than medium-size flakes;
\- medium-size flakes more abundand than small flakes.

The same analysis is summarised in Table 19. It should be noticed that according to our analyses none of the materials were

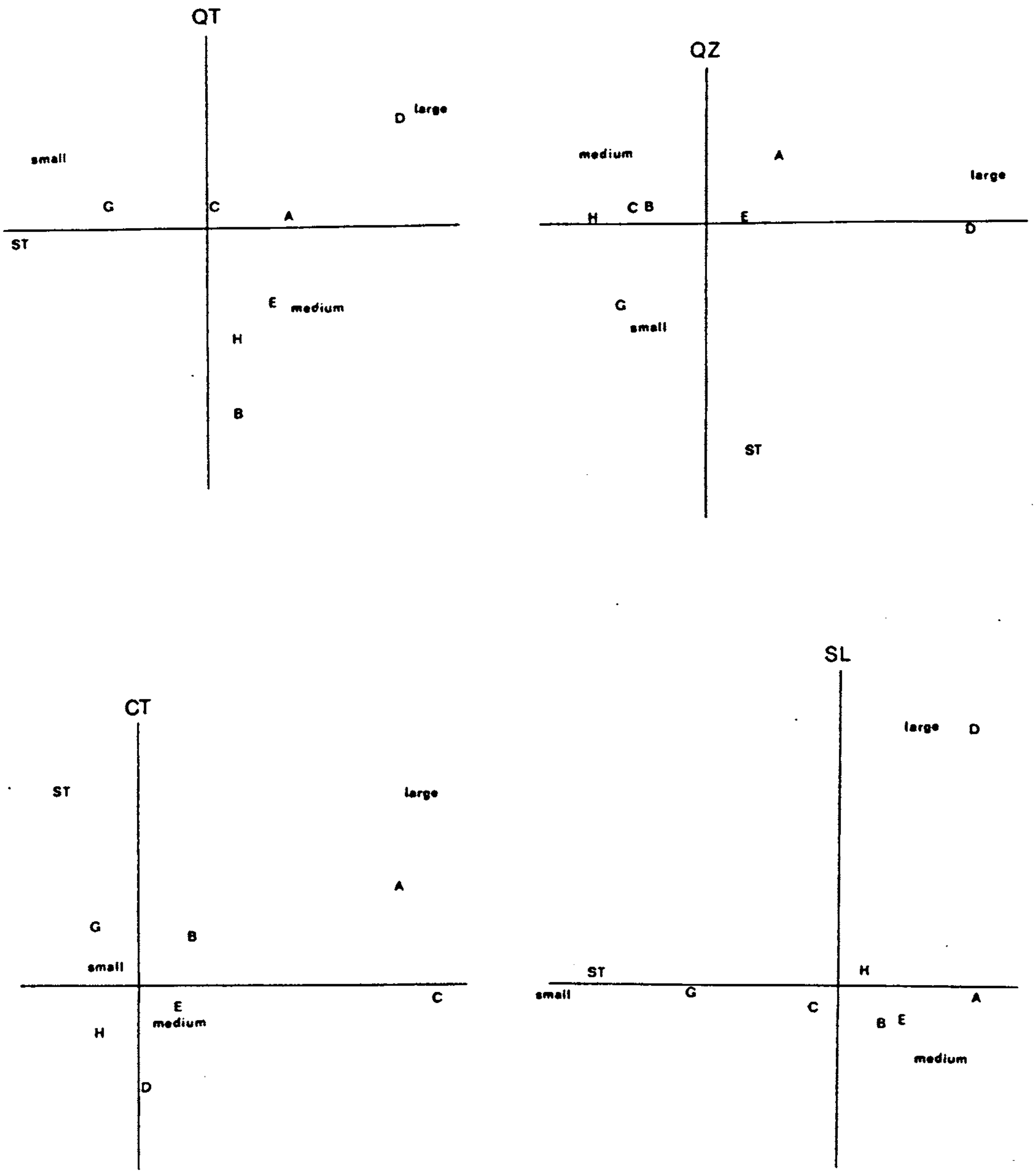

Figure 32. Correspondence analysis showing relationship between small, medium, and large flakes and assemblages within four raw materials.

intensively reduced on site A. On site C only quartz appears to be flaked. In contrast all four materials were intensively reduced on sites G and ST.

Another way of reading Figure 33 (p.198) and Table 19 (p.193) is to analyse raw material treatment across the sites. Two common local materials, quartzite and silcrete have been flaked/reduced on only two sites, G and ST, and were generally transported to the sites in ready forms such as flakes or tools. The third common local material, quartz, has always been knapped on the site (except site A). Chert, an uncommon and mostly 'non-local' material, has been flaked/reduced on all but two sites (A and C).

Overall reduction

In an attempt to integrate three sets of evidence: mean size of artefacts; degree of core reduction; and reduction reflected by flake size, I tabulated the results separately for different types of raw material.

Table 20: quartzite

site	mean weight of artefact (g)	well exploited %	cores mean weight (g)	dominant flakes
A	14.3	59.9	102.2	medium-size
D	10.9	74.5	83.7	medium-size
E	4.9	74.9	36.7	medium-size
G	4.9	76.9	92.3	small

Evidence compiled for quartzite (Table 20) suggests that large blanks (cores and possibly flakes) were brought into site A and little flaking took place on the spot. Considerably smaller blanks were carried into site E and there is no evidence of intensive on-site reduction. The highest proportion of well exploited cores and dominance of small flakes suggest that intensive reduction took place on site G. Here discarded cores are moderately large due to nearby source of raw material.

Table 21: quartz

site	mean weight of artefact (gram)	well exploited cores %	mean weight (g)	dominant flakes
A	4.2	56.6	40.6	medium-size
B	1.8	61.0	16.3	small
D	1.5	52.3	22.0	small
G	1.4	64.2	12.9	small
H	1.5	79.3	13.6	small

Quartz (Table 21) has been brought on to site A in the form of relatively large, egg-size pebbles and only slightly exploited. On other sites quartz pebbles/cores rarely exceed the size of a walnut. Quartz has been flaked on all other sites with heavy reduction taking place on sites H and G, less intensive on site B (due to the ample local supply) and moderate reduction on site D.

Table 22: chert

site	mean weight of artefact (gram)	well exploited cores %	mean weight (g)	dominant flakes
E	1.1	90.0	8.9	small
H	0.8	77.2	12.0	small

Chert (Table 22) seems to be the most intensively exploited raw material but only two sites provide evidence sufficient for statistical observations. A higher degree of reduction is visible on site E. Site H, located near some local sources of chert, (not high quality) shows slightly less intensive reduction, but probably larger blanks (indicated by heavier cores and lighter flakes[3]). The overall small-size of chert and intensive

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[3]. Consistent flaking requires larger blanks/cores and this in turn results in relative abundance of small flakes. Mean weight of flakes are 0.84g for site E and 0.61g for site H.

reduction suggest that chert was generally a non-local material (with exception of site H), and therefore expensive in procurement and transport.

Table 23: silcrete

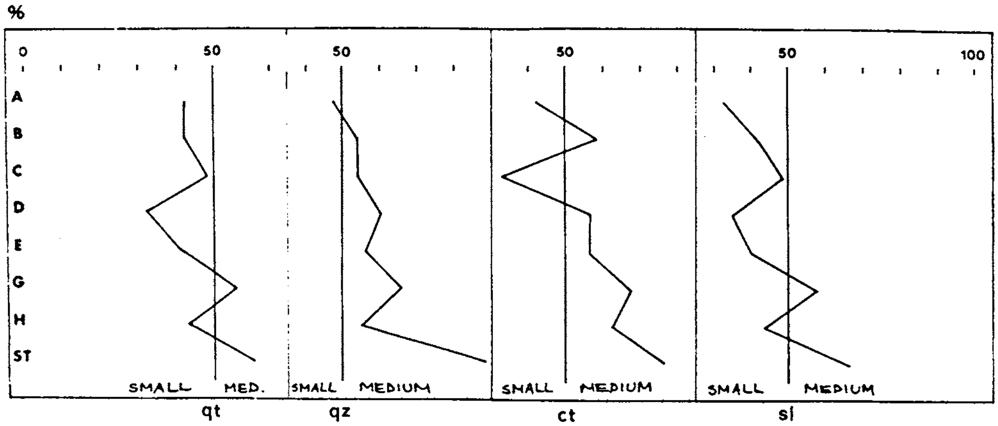
site	mean weight of artefact (gram)	well %	exploited cores mean weight (g)	dominant flakes
A	8.3	70.0	31.5	medium-size
B	2.1	90.9	17.9	medium-size
C	5.5	75.0	148.5	medium-size
E	4.5	61.9	18.9	medium-size
G	2.3	80.0	24.4	small
H	3.2	93.5	29.3	medium-size
ST	3.1	69.2	22.8	small

Silcrete (Table 23) has been most expediently used and rarely flaked on site C, due to an abundant local supply of both the material itself and ready flakes. Silcrete brought on to site C was predominantly in the form of medium-size to largish flakes.

In contrast silcrete has been most reduced on site B (both all-artefacts and cores) but only consistently flaked on sites G and ST.

While the pattern of some assemblages can be easily explained in terms of raw material supply and quality (eg. quartzite on site G, silcrete on site C, chert on site H), the patterns of other sites require an explanation where quality and demand is considered.

The large quartzite artefacts on site B are one example. There is neither a specific source nor an overall scarcity of quartzite in the site vicinity. Quartzite cores are of average size (96.0g) but infrequent, while flakes are smallish (3.3g). What accounts for the large mean size of quartzite are stone objects classified here as "shatter". Its distinctive features



Relative frequency of small and medium-size flakes. Four diagrams are placed alongside each other for easy visual comparison. Vertical axis represents 50% for each type of raw material. Small flakes are on the left and medium-size flakes on the right side of a zig-zag line showing relative abundance (expressed in %) of different size flakes for each site in the four types of raw material. For example silcrete on site A shows about 30% of small and 70% of medium-size flakes, while silcrete on site ST shows nearly 70% of small and about 30% of medium-size flakes.

Figure 33. Relative frequency of small and medium-size flakes.

are one or more surfaces resulting from splitting but not flaking, and the absence of any use-wear or modification characteristic of other artefacts such as cores, flakes, hammerstones and grinding-stones. "Shatter" may have been occasionally 'produced' as the side-result of flaking (especially poor quality material), hammering, pounding, or crushing but without any use-wear distinctive of other categories of artefacts. Some "shatter" resulted from heat and can be associated with heat-retainers and cooking-stones. Non-heat "shatter" measured against the number of quartzite flakes is especially abundant on site B, with one piece for every four quartzite flakes (3.9 against all-sites mean 14.3) and it is relatively heavy (17.6 g).

Bearing in mind that quartzite is the most suitable local material for heavy tools it can be assumed that some jobs performed on site B required the casual/instant heavy 'implements' which are poorly defined in archaeological material due to the lack of intentional modification and well developed use-wear.[4]

Evidence which corroborates this assumption comes from site A, associated with extracting quartz nodules from local conglomerate. Here non-heat quartzite "shatter" is relatively common (one piece for every seven flakes) and heaviest (35.6 g).

This reduction pattern provides a glimpse of an overall strategy which can be attributed to the local subsistence system. Although the small number of assemblages included in this study prevents me from elaborating on this subject, it is of interest to note that site G, located next to the material source, and site ST, distant from any material for flaking, display a similar tendency towards on-site reduction. This similarity results from a quite different strategy of provisioning the sites with hardware implements, and it demonstrates the complexity which is so easy to overlook in archaeological evidence.

SIZE OF ARTEFACTS AND INTENSITY OF HABITATION

In the light of the foregoing analysis some broader conclusions can be made about the patterning of raw material distribution and flaking technology. The two assemblages characterised by large artefacts -A (8.1 g) and C (5.4 g)- can be reasonably well explained by material source, the form in which stone was brought on the site and its consequent treatment. Assemblage D, also characterised by large artefacts (6.5 g), cannot be explained in a similar manner. The suggestion that it is dominated by quartzite, brought on site in the form of largish packages and not reduced any further, offers a reasonable explanation. However, it cannot be read as a clear influence of supply because nearby site E, also dominated by quartzite, is characterised by small artefacts (3.6 g).

Artefact size in two assemblages, G (2.3 g) and ST (1.9 g), can be explained by a) intensive reduction due to quartzite flaking and b) long distance to raw material sources, respectively.

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[4]. For example, it has been recorded that handstones and other impromptu adopted large stones were used to break animal bone. 'Flat stones and cobbles used to smash goanna bone [...] do not exhibit any signs of use' (Nicholson and Cane 1991:346).

Sites E (3.6 g) and H (2.3 g) and B (2.8 g) are characterised by small artefacts. This reduced size cannot be satisfactorily explained in terms of raw material supply. It is true that site B is dominated by quartz which tends to be small, and site H by quartz and chert combined, which also shows a tendency to small size. However site E is dominated by quartzite which, unless intensively reduced, tends to be associated with larger artefacts.

It seems that there is another factor responsible for reduction patterns among the sites and raw materials. This I termed tentatively as intensity of habitation (or camping)[5].

Gould (1978:824) made the observation that 'waste flakes and discarded cores [...] found in habitation context [...] represent a narrower size range [...] with the means tending towards considerably reduced sizes.' Although he attempted to contrast campsites with quarry sites, it would be worthwhile exploring whether the same principle applies to intensity of habitation (also Schiffer 1972, 1987). Gould's data suggest that repetitive and/or extended habitation manifests itself by significant reduction of stone artefacts (habitation sites) while task-specific sites (eg. quarry) display less reduction and wider size range of stone artefacts. Sites associated with transient occupation seem to display a narrow range of activities (involving stone artefacts) and effectively shift towards the task-specific end of the spectrum. Therefore it may be possible to recognise the relative intensity of occupation by degree of reduction of stone material.

In the first attempt to assess this relationship I compared the sites by two variables: density of scatter and mean weight of artefacts. Although figure 34 (p.201) shows an irregular

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[5]. By intensity of habitation I mean the number and duration of camping episodes and range of camp-activities. Low intensity denotes fewer and short episodes of camping resulting in the narrower range of camp-activities (expected on transient campsites). In contrast high intensity signifies more frequent and long duration camping events and consequently the wider range of activities (expected on frequently and long occupied locations). Ultimately this would translate into total added duration of camping events and total number of inhabitants that ever camped on the site, reflected by quantity of artefacts and range of activities (compare Hughes and Lampert 1977; Hiscock 1981).

pattern which cannot fit a neat regression curve there is something to be learned from this diagram. First of all, sites A and G separate themselves from other sites by virtue of being ’too dense (site G) or too heavy (site A).’ The remaining sites seem to form two clusters: a) assemblages C and D characterised by low density and heavy artefacts, and b) assemblages B, E, H and ST characterised by high density and light artefacts.

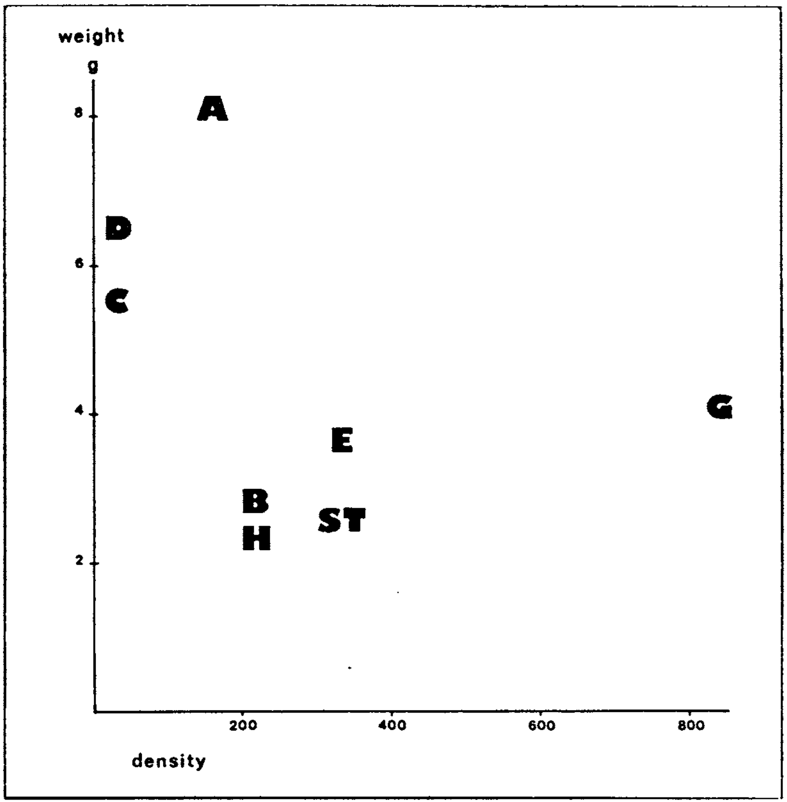

Figure 34. Relation between mean weight of artefacts (vertical axis) and density of artefacts per $1m^2$ (horizontal axis).

Figure 35 (p.202) helps to analyse these variables in a more meaningful manner. Sites B, E, H, and ST are in the box which represents dense scatter and light artefacts; while sites C and D are in the box representing sparse scatter and heavy artefacts. Site G must be put into the first box (high density) but it shows a tendency towards relatively heavy artefacts represented by box number 3; similarly site A must be put into fourth box (heavy artefacts) but because of its density it gravitates towards box number 3.

It would be difficult to overlook the predictive quality of this diagram where box number 3 represents preparatory knapping and primary flaking deposit. Such materials are characterised by high density and overall heavy artefacts but with a large component of small flakes resulting from on-site reduction.

There are three obvious factors contributing to the high density scatter: a) limited area available for camping; b) frequent stone reduction performed on site, and; c) secondary reduction and recycling due to intensive camping activity. Artefact size depends upon a) distance from the source of stone material; b) degree of on-site reduction, and; c) intensity of camping such as length and frequency.

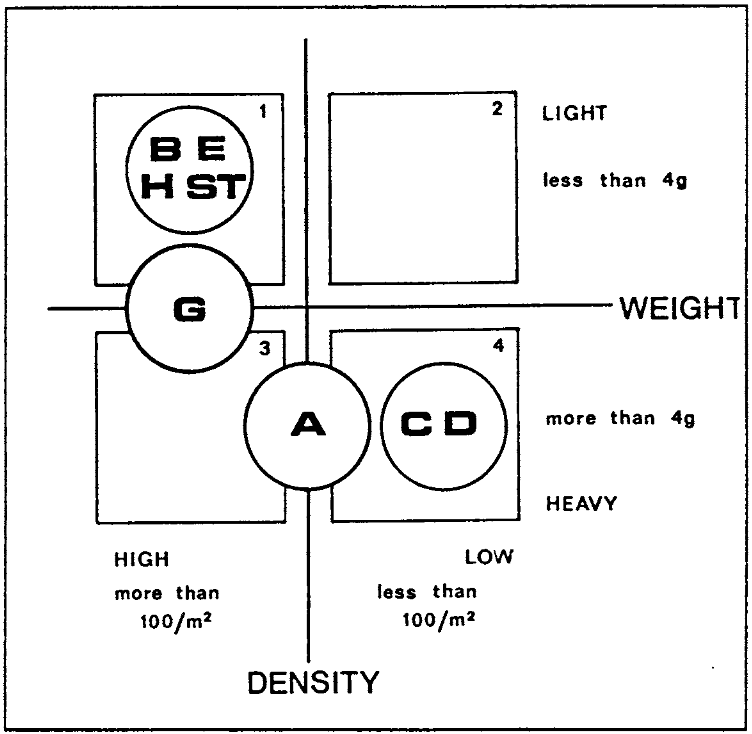

Figure 35. Interpretative diagram groupping assemblages according to density and mean weight of artefacts (no scale within boxes).

Taking these factors into consideration we can now attempt an explanation of the relationship between mean size of artefacts and density of scatter. It seems that habitation intensity is reflected by high density scatter and low mean weight of artefacts. This in turn translates into moderate to intensive primary flaking and intensive secondary reduction of stone material.[6]

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[6]. By reduction, in this context, I mean secondary modification such as production and alteration of implements; this involves retouching, re-sharpening and recycling of stone material, mostly flakes. In contrast, primary flaking is a regular exploitation of developed cores. Preparatory flaking is the first stage of knapping using largely unmodified stone such as blocks and pebbles procured from their sources. Preparatory flaking largely involves a core developing and shedding low quality or otherwise unwanted material. Although such knapping produces a number of useful flakes, it also leaves a significant portion of large flakes and chunky pieces as refuse. Preparatory flaking often takes place within or near the source of raw material, regular core exploitation (primary flaking) may take place within both outcrop and campsite, while further reduction (secondary flaking) is frequently associated with habitation sites.

Site ST provides a good example of primary flaking and intensive reduction while site G shows evidence of preparatory flaking, primary flaking and intensive reduction of stone material.

Site G, characterised by extremely high density (840 artefacts per 1m^2) and medium-size artefacts (4.1 g), shows a) limited area available for camping and b) evidence of intensive on-site flaking. These two factors account for the very high density because intensive primary flaking was squeezed into a very small area and so was the camping activity. A local supply of quartzite allowed preparatory flaking to be performed on the site, contributing to the somewhat largish mean of artefacts. Site G shows clear evidence of primary flaking while intensive habitation is documented by a significant reduction of stone material and variety of stone implements. These two activities combined produced very high density whereas the mean weight of artefacts has been pushed down by intensive habitation and pulled up by on-site preparatory flaking.

Characterised by intensive on-site reduction site ST comprises a very small portion of large flakes, which are common in sites with large component of preparatory flaking (eg. site G). It seems that intensive reduction has been induced by the high cost of transporting raw material from distant sources. While distance accounts for more intense reduction, extra light (small) artefacts and high density suggest intensive habitation.

The other three sites B, E and H are similar to ST, showing evidence of intensive habitation.

Two other sites C and D signify low habitation intensity with a distinctive large proportions of large to extra large flakes (6-8%). Site C, characterised by low density (30 artefacts per 1m^2) and large artefacts (5.4 g), can be defined as a low intensity campsite with lithic material supplied mainly in the form of flakes procured from the nearby quarry. Site D is of low density (30 artefacts per 1m^2) and large artefacts (6.5 g), apart from quartz there was little on-site flaking and a large portion of the materials is comprised of robust quartzite artefacts. This site is a good example of low intensity habitation.

The remaining site A, provides an example of a habitation site assocciated with stone material procurement. Site A is moderately dense (160 artefacts per 1m^2) with heavy artefacts

(8.1 g) and a relatively high proportion of large to extra large flakes (5%). Density may be partially affected by limited site area while mean weight of artefacts can be attributed to nearby stone material procurement and some preparatory flaking. This site can be characterised as having medium camping intensity.

It seems that in general high density and small artefacts reflect intensive habitation. However, this characteristic must be treated with caution because there are many other factors which may influence density and size of artefacts. When such circumstances are known (and better still, measured) density of scatter and artefact-size can be a valuable tool in the assessment and analysis of sites.

There is a limit to which raw material alone can provide an insight into variability of assemblages. However, two basic properties, -frequency and size of lithic materials- allows us to outline an informative framework of variability and associated causes.

5. Tools and raw materials

Although the supply of raw material plays an important part in the structure of assemblages it is obvious that, even within constraints of availability, the type of raw material was selected on purpose. This may be best demonstrated by the relationship between types of raw material and stone tools. Such a relationship will be explored in this section.

The term 'tools' is often used in a classificatory sense meaning artefacts with secondary modification such as retouch (eg. scraper) and discernible use-wear (eg. hammerstone). Cores are commonly regarded as modified packages of raw material to supply flakes but they may have been used as tools. For simplicity we will refer here to all secondarily modified artefacts (including cores) as tools. The term 'formal tools' will be reserved for a narrower range of secondary modified artefacts consisting of backed blades, scrapers, tulas, retouched flakes, and points.[7]

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[7]. Points are rare on the mound spring campsites (9 items in a whole sample) and for this reason they cannot be used in the analysis.

Although comprising only a small proportion of the assemblages (3.4 -7.0%) tools are often seen as diagnostic of specific cultural entities and/or kind of activity (ies). While variation between cultural traditions can be justifiably considered in a broad inter-regional study, in this research, functional variation can be assumed as the primary underlying cause for morphological diversity of tools. In other words I assume that diverse tools are made for different tasks, allowing for the gray areas where the same tool can serve different functions (eg. hammerstone used as grinder) and where some tools are not shaped according to a morphological model (eg. retouched flakes).

CORES

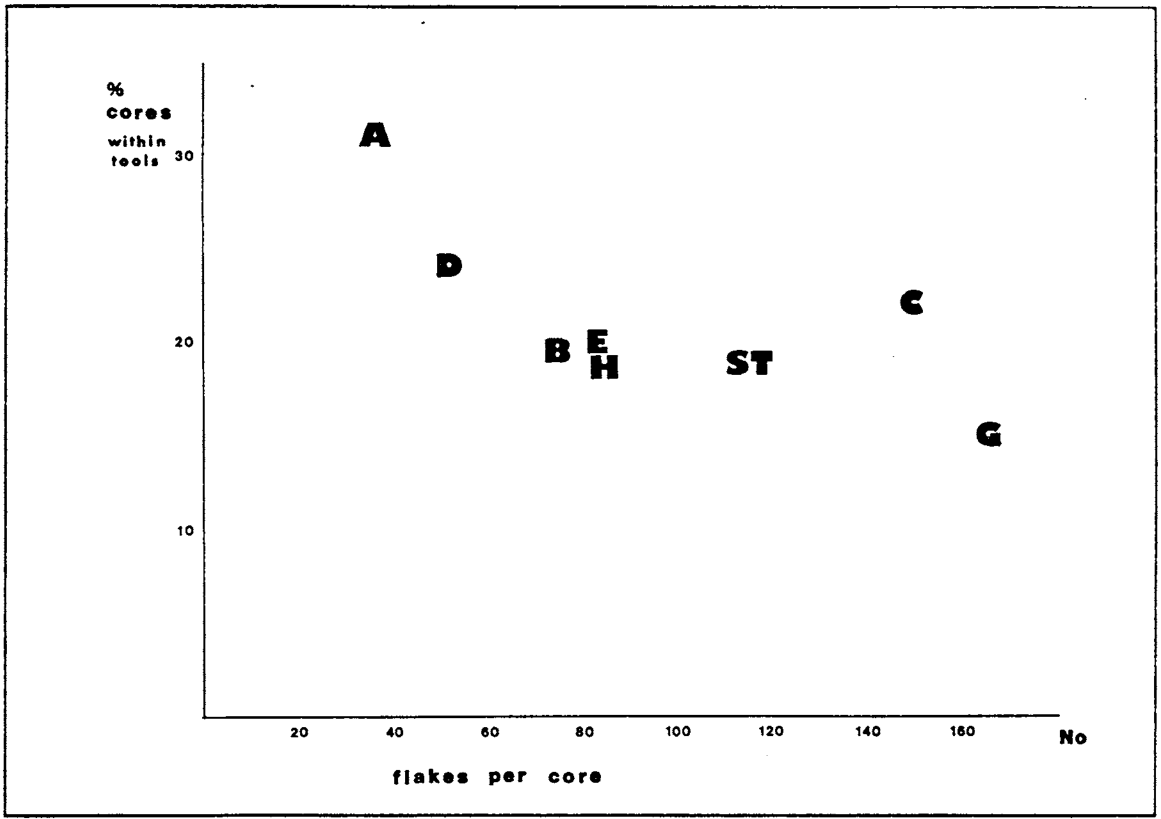

Figure 36. Flake/core ratio (horizontal axis) and frequency of cores (%) among tools.

It is often difficult to muster convincing evidence that cores were used for anything more than to supply flakes. A regularly trimmed platform edge to straighten out and/or re-dress the angle of cutting section provides the most obvious example of such evidence for use. However cores may be used effectively for a variety of cutting and chopping tasks without any additional modification (Gould 1977:164). In my sample there are only several cores with edge trimming. Although this is a subject which warrants more detailed study the quantitative data enables me to perform a cursory exploration of this problem.

It can be assumed that a high relative frequency of cores among tools indicates their importance regardless of whether they were predominantly material for flaking or used for other purposes. Also it may be assumed that if cores were meant to provide flakes, their presence on the site would coincide with a high proportion of flakes (high flake-core ratio). Figure 36 (p.205) shows the proportion of cores within tools and number of flakes per core. Three assemblages B, E and H with various degrees of on-site flaking are clustered in the centre and are characterised by about 20% of cores and about 75-85 flakes per core. This can be read as an average tendency (mean for eight sites are: cores - 21% of tools; and flakes per core - 87). Sites A and D display a high frequency of cores but flaking was only a minor component of on-site activities. From this we can infer that cores were presumably used as implements besides being a casual source of flakes.

Site G is characterised by a low proportion of cores (15%) and large numbers of flakes per core (165) suggesting that cores were predominantly involved in flaking. Site ST displays an average proportion of cores (18%) but a far larger than average number of flakes per core. This is consistent with intensive reduction that took place on site ST and cores seems to be involved in flaking more than on sites B, E and H.

Site C displays a relatively high proportion of cores (22% of all tools) which is partially due to the overall scarcity of formal tools. Although little reduction was performed on the spot, many flakes were brought to the site from the local quarry. Consequently site C is shifted to the right part of the diagram (high flake-core ratio). Because little flaking was performed on the site, the cores present may have been used as implements and a casual source of flakes.

It must be remembered that lithic material on the mound spring campsites underwent a long process of reuse and recycling which constituted an integral part of site formation. While flakes tend to proliferate by breakage and intentional division, cores tend to be modified beyond recognition. Indirect flaking with an intermediate implement (eg. punch) enables almost complete reduction of some cores and precious material such as chert may have been utilised in such an intensive manner. Some cores (especially quartzite) may have been used as cooking stones (eg. site ST) and others broken to pieces by different casual applications. Moreover there is an obvious variation in the use of different raw materials. For example, while it was desirable to reduce chert cores to their limit, many quartz cores cannot be reduced much further (intermediate flaking of quartz is ineffective, Dickson 1977) and common availability of this material rendered such attempts unnecessary.

Ethnographic observations suggest that some larger cores of metamorphic materials and quartzite were used predominantly as wood chopping tools (eg. Hayden 1976:185, 1979a:79). If used consistently for some length of time such tools are likely to be resharpened with discernible edge trimming. There are only several specimens with such trimming in my sample of cores. When used in an off-site context such cores are unlikely to receive any additional trimming (Gould 1977:164) but on campsites they may be further re-used for flaking. Smaller cores of fine grained stone and quartz may have been used as an effective chisel or adze (Dickson 1977:98). However ethnographic

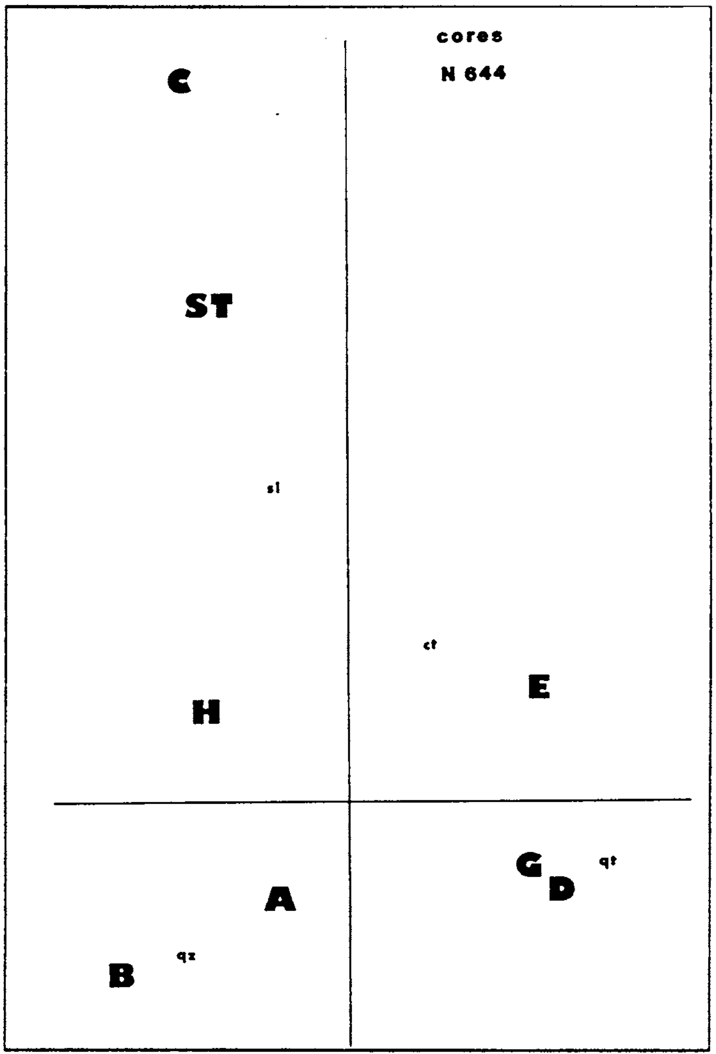

Figure 37. Correspondence analysis showing relationship between cores and raw materials.

identification of core function in the Western Desert suggests that a majority of cores (90%) were simply sources of flakes (Cane 1984:149). With this statistical assertion in mind we can now proceed with the analysis of cores in relation to raw materials.

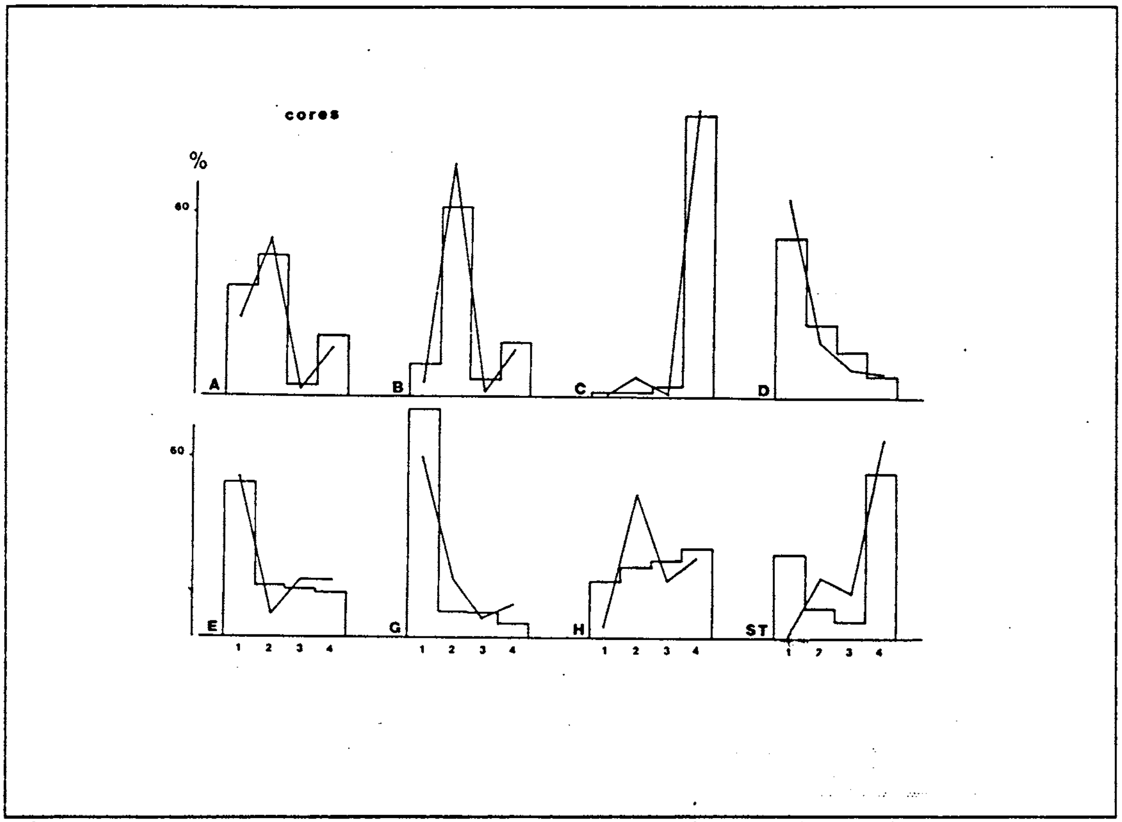

Figure 38. Frequency of raw materials (bars) and cores (lines) within assemblages.

Figure 37 (p.207) demonstrates the relationship between cores and raw materials. The same data are represented in figure 38, showing eight raw material frequency diagrams (bars) and superimposed on them core frequency diagrams (lines). In general, core frequency diagrams follow contour of raw materials with some minor variations. However, on site H there is an unusual abundance of quartz cores in expense of others, especially quartzite cores. It is clear that on the whole the abundance of cores is related to the dominant local supply of raw material (compare Gould 1980:145-46). Such local material has often been most extensively exploited where there was no conflict between supply and demand.

Site H provides an instructive exception. Here abundance of quartz cores is over-emphasised by the relative scarcity of others, especially quartzite cores, suggesting that quartzite has usually been flaked off-site (several isolated quartzite knapping floors were observed within site vicinity). Somehow a similar pattern is demonstrated by site ST. Here quartzite cores were rarely brought on the site or completely reduced and/or recycled (eg. heat retainers).

Although it is easy to calculate the number of flakes per core for every type of raw material it is far more difficult to make good use of these data. It is unlikely that such numbers represent flakes being struck from the average core. The main problems are that a) flakes tend to proliferate by breakage even a long time after the site has been abandoned (eg. stock traffic); b) cores tend to vanish by means of reuse and recycling, and; c) flaking has often been performed off-site. However some qualitative observations can help to understand the pattern of flakes to core ratio.

Quartzite has been flaked with a hard hammer and consequently a large portion of medium-size to moderately-large flakes have been split into two comparable parts during flaking. I re-fitted several of these split flakes: each part being about half of a flake complete with its own part of the striking platform, bulb of percussion, point of percussion, and termination end. This flaking produced relatively more flakes and more potential cutting implements (compare Wright 1983:121).

Quartz was easy to procure in the form of small pebbles and it appears to be flaked most often on the sites. Cores were often small and required anvil flaking. However bipolar flakes are virtually absent, suggesting that flaking was directed towards obtaining a number of flakes and possibly small core tools that may have been used as an effective woodwork implement similar to chisels (Dickson 1977:98). Although more systematic flaking was occasionally performed on quartz, larger cores of about 100 g which permitted such flaking are rare.

Chert was exploited in the most intensive manner and many cores probably disappeared in this process. Chert cores are rare and consequently the flake to core ratio is exceptionally high. This is also due to the fact that chert flakes underwent the most intensive reduction. Both cores and flakes suggest that indirect percussion was commonly employed in chert flaking.

Silcrete is a common local material, probably most diverse in its properties, qualities and applications. Silcrete was often flaked off-site with a hard hammer.

Cores are not specific to any single type of raw material. However, a core can be seen as the immediate source of sharp cutting edges (flakes) and steep chiselling edges (some flakes and the core itself). In this context it is logical that many cores are associated with the most common 'instant' raw material, quartz, a potential source of very sharp flakes.

Considering its properties and availability quartz appears to be a local material most suitable for instant procurement and application. Quartz has always been (except at site A) flaked on site and cores of this material are represented by the largest number in the sample - 239 (for comparison, quartzite: 199, silcrete: 130, chert: 66; see Fig. 38, p.208). Flakes produced from a quartz core are usually small, thin and sharp, ideal instant cutting implements (Dickson 1977:98; Kamminga 19982:118; Knight 1988:4; in experimental work a quartz flake proved to be far more efficient in cutting meat than a similarly used quartzite flake, Fullagar 1986:191).

Table 24: mean weight of cores (g)

site	QT	QZ	CT	SL	N
A	117.2	52.9	8.1	189.2	57
B	216.6	18.8	11.6	17.2	132
C	-	2.7	-	212.1	16
D	111.5	20.2	8.9	29.2	106
E	41.9	13.4	8.6	28.4	103
G	134.7	11.8	8.2	35.7	97
H	43.1	16.9	10.8	33.5	113
ST	-	20.0	8.3	54.7	20

Finally it is instructive to consider the weight of the raw material since often this is the factor exerting constraints over the economic activities. Table 24 shows the mean weight of cores within each type of raw material. These data support the view that an instant supply of flakes was best served by light quartz cores which were easy to procure and carry to the sites. However, quartz flakes, efficient in cutting, were far less suitable for other tasks and in the long term they must have been supplemented by other raw materials.

FORMAL TOOLS

Figures 39 and 40 (pp.211-212) show the relationship between tools and raw materials. The largest number of cores are made of quartz. Most of the backed blades are made of quartz and silcrete. Tulas are almost exclusively made of chert and silcrete. Chert seems to be a favourite material for scrapers while retouched flakes are often made from the relatively coarser quartzite. These associations can be read as an overall tendency towards using different materials for production of specific tools. Figure 41 (p.214) shows the frequency of tools on all eight sites.

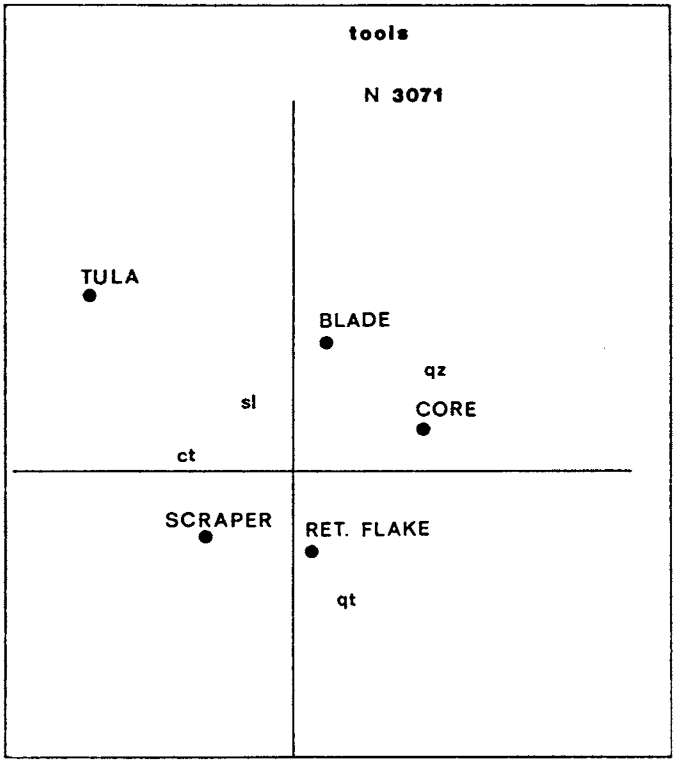

Figure 39. Correspondence analysis showing relationship between tools and raw materials (qt: quartzite; qz: quartz; ch: chert; sl: silcrete).

In the following paragraphs I will discuss how this general tendency is exemplified or contradicted by particular assemblages. It should be clear that the selection of raw material for the production of specific tools was achieved through a compromise between the most suitable material and the local supply. In some cases local material was used in preference to the most suitable stone; in others a specific type of raw material was procured in preference to the locally available type of stone.

Retouched Flakes

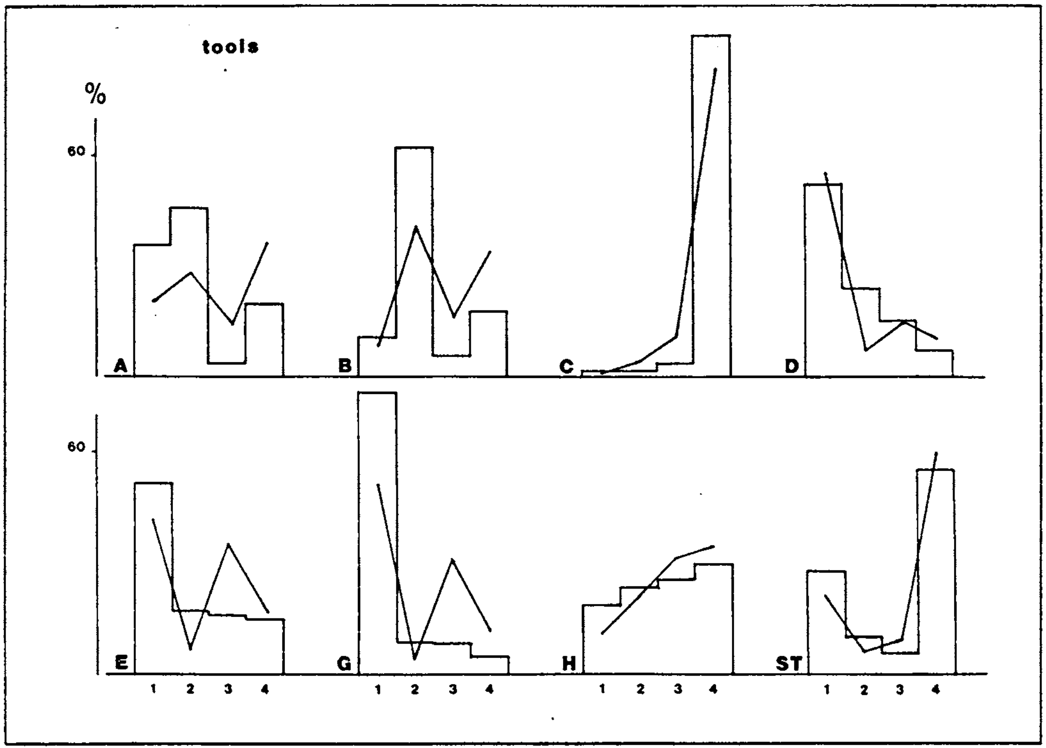

Figure 40. Frequency of raw materials (bars) and tools (lines) within assemblages (1: quartzite; 2: quartz; 3: chert; 4: silcrete).

It seems that ethnographically a retouched flake is an instant tool applied to a variety of woodcraft (eg. Gould 1977; Hayden 1976, 1977, 1978, 1979a; Cane 1984, 1988, Kamminga 1982). Retouch can be seen as the first obvious use-wear and/or initial modification by edge maintenance (cf. resharpening). On the whole the degree of this modification is low and the morphology of the flake basically unaltered. A retouched flake is a good example of an implement developed and modified by use rather than preconceived in design and morphology.

Retouched flakes can be defined as instant tools in relation to other formal tools because they were likely to be selected from among ordinary flakes, used in an expedient manner and discarded well before they acquired a specific shape and/or standardised form of working edge.

Although it is difficult to generalise about the origin and possible application of retouched flakes it seems that by and large they were used in rough cutting and 'scraping' tasks, broadly parallel to the function that can be served by broken glass. Retouched flakes are often associated with quartzite, a commonly available but coarse material.

Figures 42 and 43 (p.215) show the relationship between retouched flakes and raw materials.

On the sites dominated by quartzite (D, E, and G) most retouched flakes are made of quartzite, with chert being the second most preferred material and quartz distinctively the last.

On the sites dominated by quartz (A and B), quartz retouched flakes are very common with silcrete being the first (site A) or the second (site B) on the list.

On the sites dominated by silcrete, such as C and H, silcrete is the most preferred material for retouched flakes while quartzite and quartz are last. On site ST, also dominated by silcrete, silcrete retouched flakes are the most common, while quartzite is the second favourite material with quartz being the last.

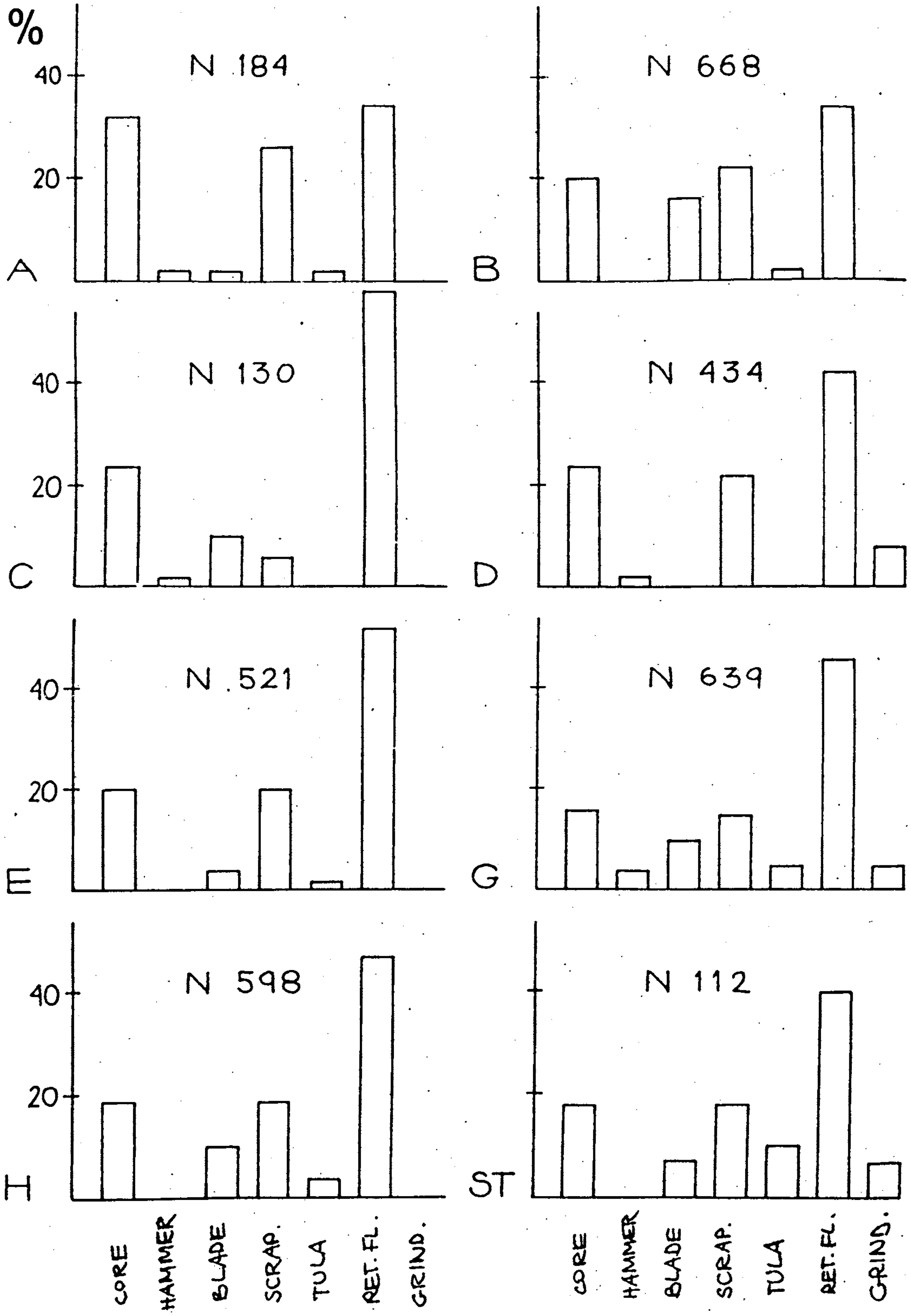

Figure 41. Relative frequency (%) of tools within assemblages, all raw materials combined.

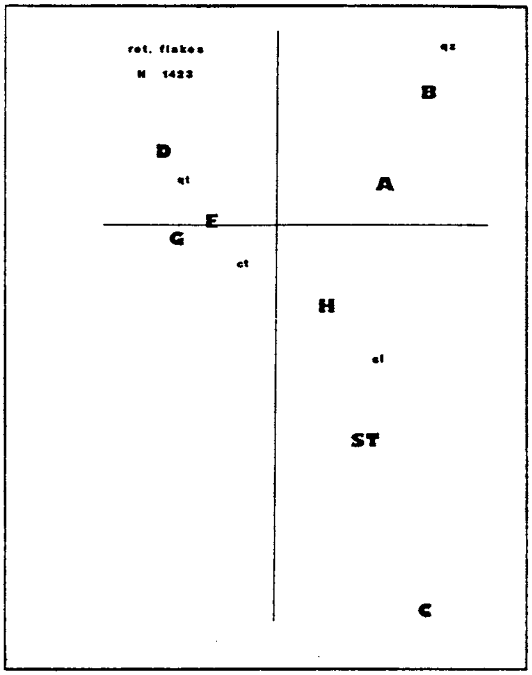

Figure 42. Correspondence analysis showing relationship between retouched flakes and raw materials, by assemblage.

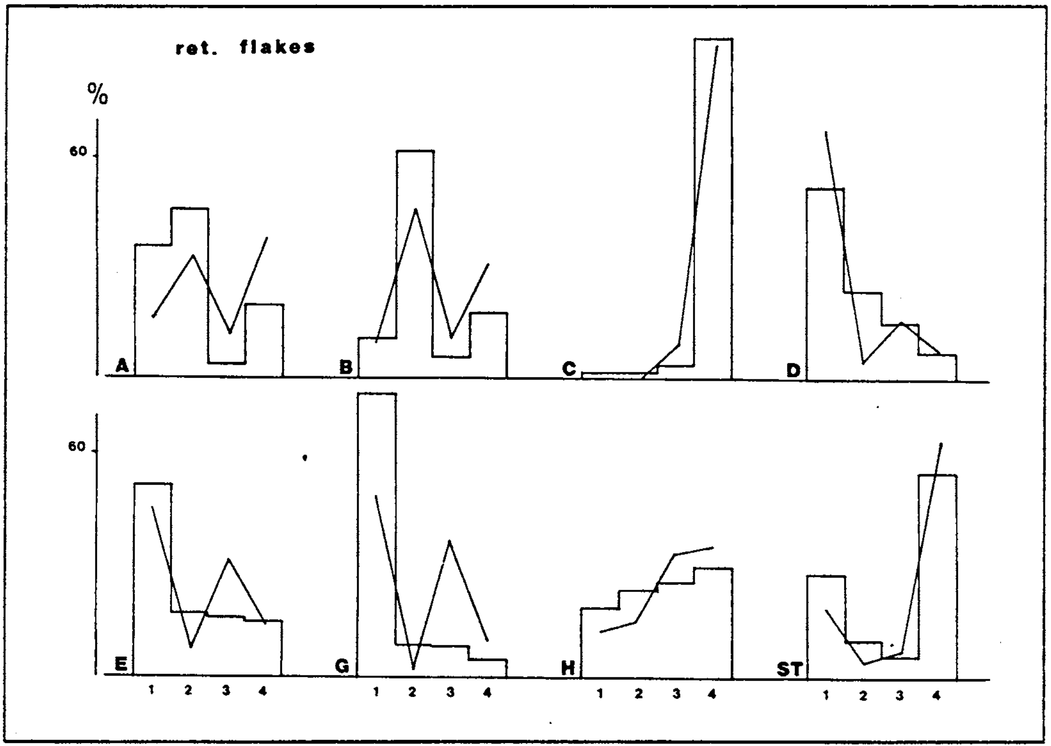

Figure 43. Frequency of raw materials (bars) and retouched flakes (lines) within assemblage, (1: quartzite; 2: quartz; 3: chert; 4: silcrete).

Scrapers

In general scrapers are a sub-category of retouched flakes with more formalised morphology and especially well developed working edges. Development of this working edge results from repetitive use and resharpening. A scraper seems to be a more specialised, standardised, and probably more precise, woodworking tool than a retouched flake. If this is true it is only logical that most scrapers are associated with chert and silcrete.

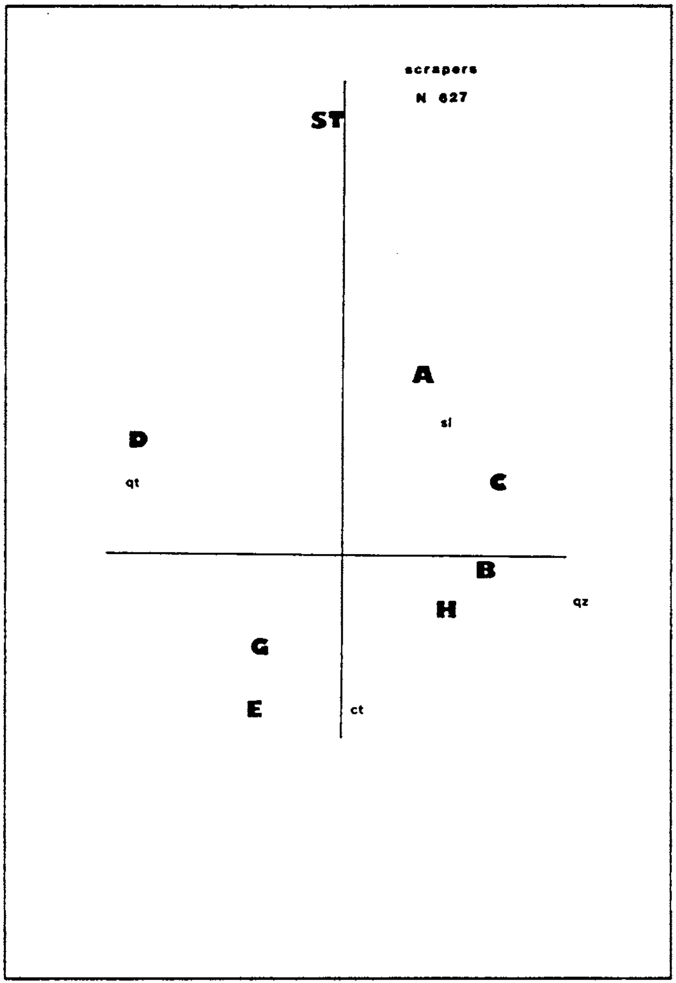

Figure 44. Correspondence analysis showing relationship between scrapers and raw materials, by assemblage.

Figures 44 and 45 (pp.216-217) show the relationship between scrapers and raw materials. On sites A, B and C silcrete is the most favoured material before chert. On sites E and G chert is the first preferred material for scrapers, with quartzite the second before silcrete. On site H chert is dominant before silcrete, while on site ST, silcrete is preferred before quartzite. On site D half the scrapers are made of quartzite and the remaining half is divided equally between chert and silcrete.

It is noteworthy that quartz is always the least preferred material for scrapers. This must be due to the properties of quartz and the difficulties in retouching and repetitive edge maintenance. This negative correlation between scrapers and quartz provides other, circumstantial, evidence supporting a view that scrapers developed through use and repetitive edge maintenance (Ranere 1975; Dibble 1984, 1987).

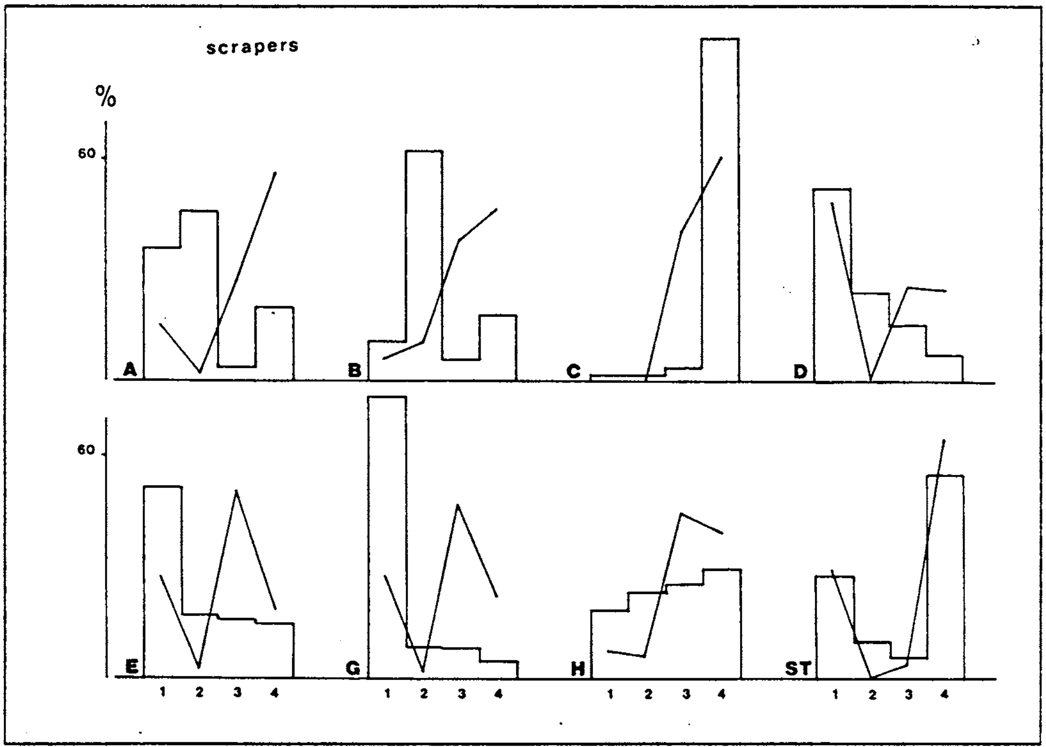

Figure 45. Frequency of raw materials (bars) and scrapers (lines) within assemblages, (1: quartzite; 2: quartz; 3: chert; 4: silcrete).

Tula

In the light of ethnographic accounts the tula appears to be a sophisticated implement, designed for prolonged work with hard wood (Gould 1968, 1977, 1980; O'Connell 1974; Kamminga 1985, 1988). For this reason hard fine-grained material such as chert or fine silcrete was most desirable. In technological terms a tula is a specific type of flake which needs to be pre-shaped during core preparation and is obtained by a specific, dificult method of flaking. The core itself must be relatively large (such large blocks of fine silcrete and especially chert, are rare within the mound springs country) and therefore tula production is often associated with specialised quarries. Tula flakes are known to be transported and probably traded over long distances (Hiscock 1988; Hiscock and Veth 1991).

Figures 46 and 47 (pp.218-219) show the relationship between tulas and raw materials. On site A tulas are made of chert and silcrete in equal proportions. On sites B, H and ST most tulas are made of silcrete rather than chert. On sites E and G most tulas are made of chert rather than silcrete. The remaining sites do not contain enough tulas for statistical observations.

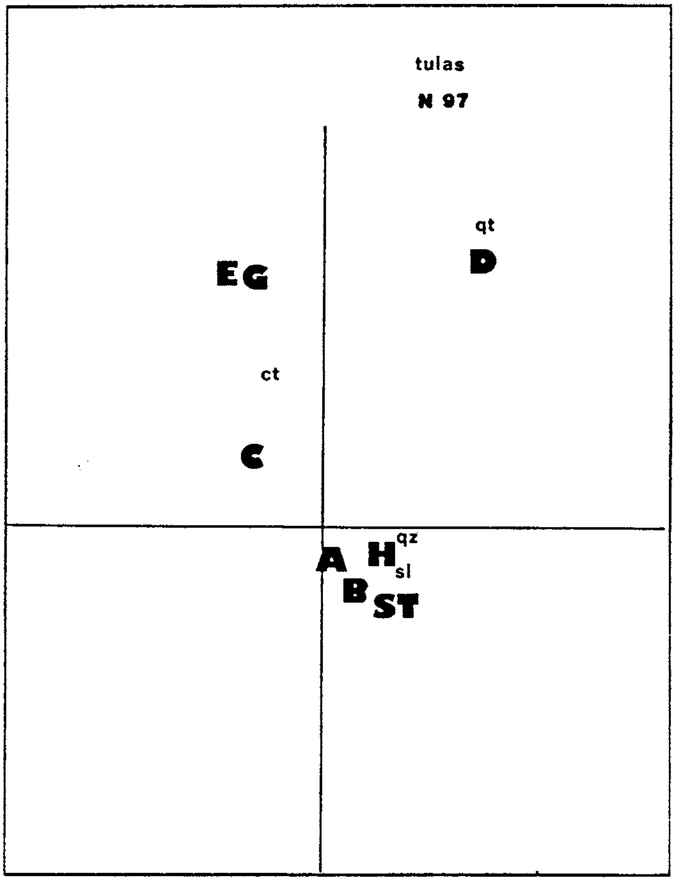

Figure 46. Correspondence analysis showing relationship between tulas and raw materials, by assemblage.

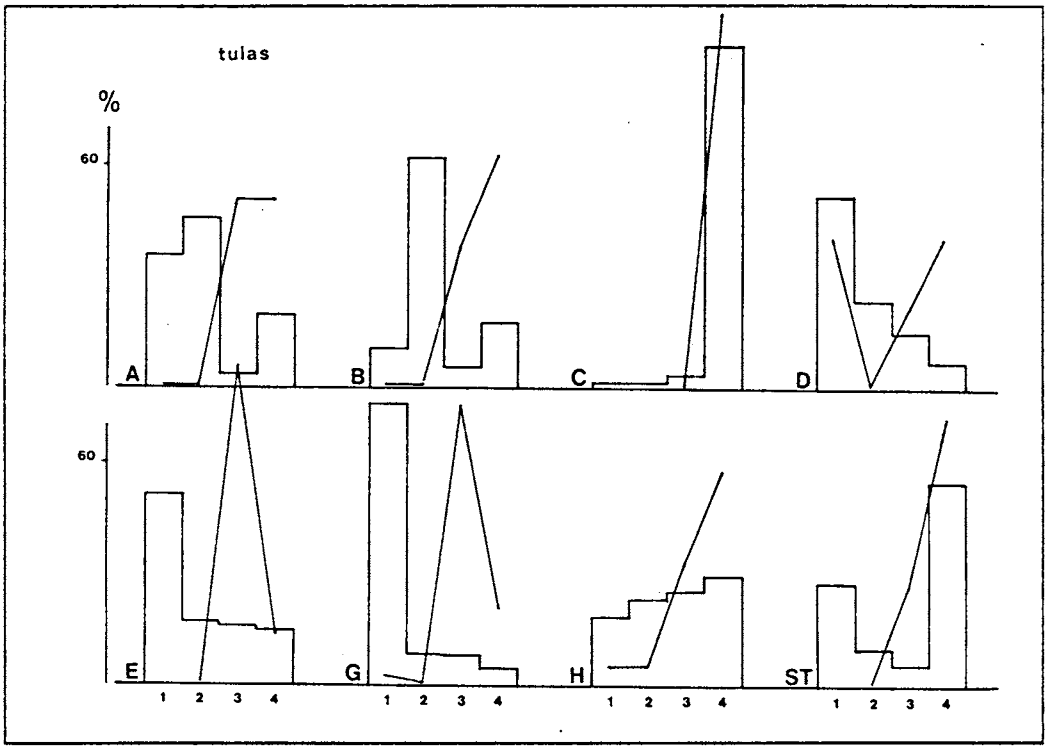

Figure 47. Frequency of raw materials (bars) and tulas (lines) within assemblages, (1: quartzite; 2: quartz; 3: chert; 4: silcrete).

Backed blades (geometrics)

Most backed blades are made of silcrete and quartz, supporting the supposition that cutting was their general purpose. The sharp side was the working edge of the implement (regardless of whether it was a component of a hunting weapon, fighting knife, or blade used in domestic duties and crafts, Kamminga 1980; McBryde 1984; Boot 1986; Fischer 1985).

Figure 48 and 49 (pp.220-221) show the relationship between backed blades and raw materials. On site B about 80% of these implements are made of quartz and silcrete. 60% of the backed blades are made of local quartzite on site G, while on site H they are made from quartz, chert and silcrete, each material accounting for nearly one third of a total. The most outstanding departure from the overall tendency and supply of raw material is site E, where 65% of backed blades are made of chert - a material neither preferred nor supplied locally. Backed blades on other sites are far less numerous and their distribution is roughly parallel to the frequency of raw materials.

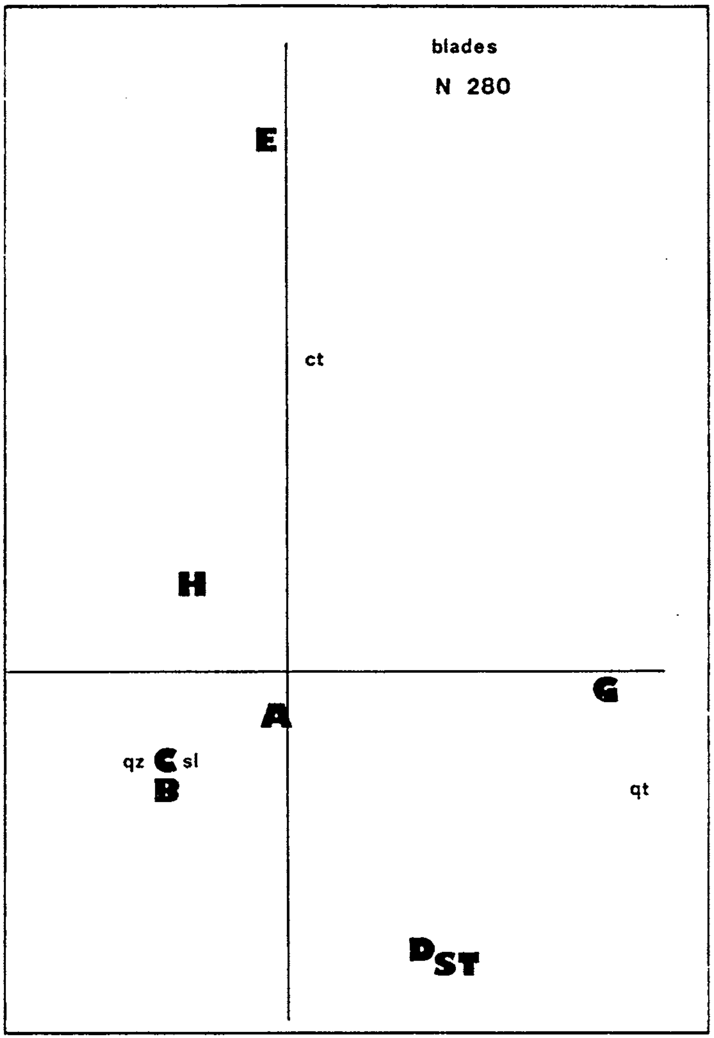

Figure 48. Correspondence analysis showing relationship between backed blades and raw material, by assemblage.

Other Tools

Uni-facial points (pirri) are extremely rare and no statistical observations are possible. However all 10 points in my sample are made of silcrete and they were found on the sites with a relatively large proportion of backed blades (sites B, E and G).

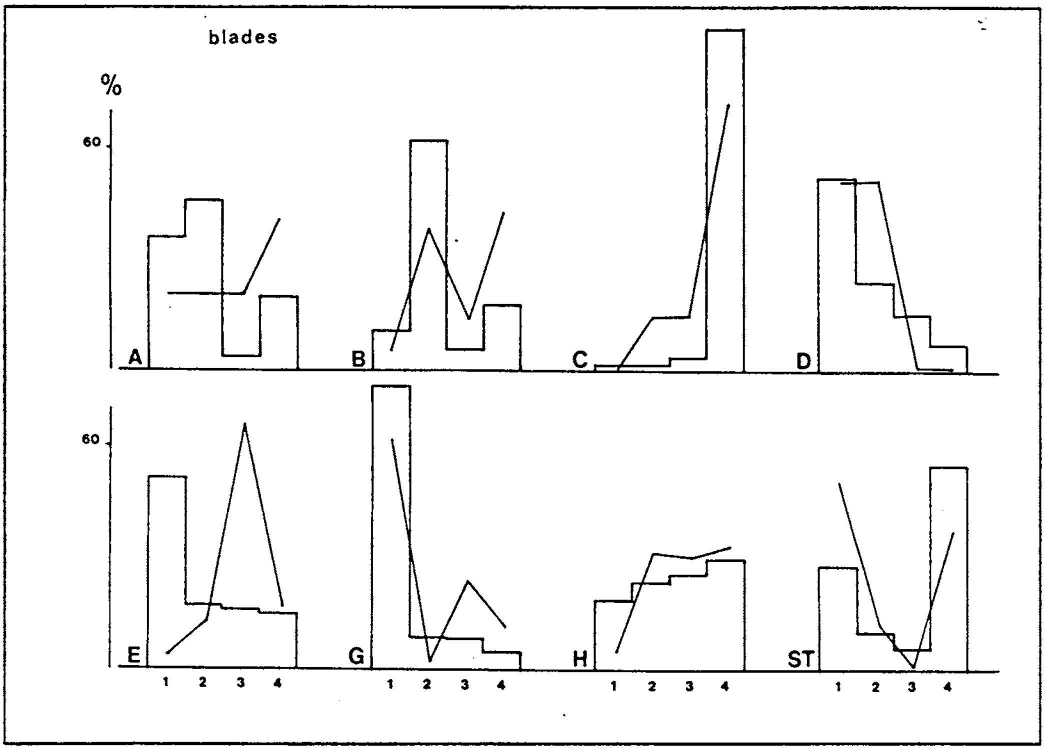

Figure 49. Frequency of raw materials (bars) and backed blades (lines) within assemblages, (1: quartzite; 2: quartz; 3: chert; 4: silcrete).

Grinding stones are made exclusively of indurated sandstone[8] (grinding bases) and/or quartzite (top stones). This must be related to the property of the material required for the job. Fine-grained material of a good flaking quality is not fit

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[8] Although McBryde (1992 seminar) considers sandstone to be a common raw material in the Lake Eyre region, in the area of this study such material is rare. The sandstone in a few isolated pockets that I know is not consolidated enough and is coarse; there is no evidence of use of these sources for production of grinding bases. Well-known quarries for grinding stones in the region are all distant from the mound spring sites included in this study. The closest quarry, at Anna Creek, is approximately 50 km from Strangways Springs (site ST). Quarries in the Flinders Ranges are about 200 km from Welcome Springs (sites A and B). Small quartzite ranges to the south of the mound springs can possibly provide useful sandstone (although I have not had the opportunity to inspect these localities); from the map alone it appears that the closest potential sources may have been about 15-20 km from Wellcome Springs and Wangianna but much further from other mound springs. For this reason I consider sandstone to be non-local material, provision of which required considerable medium to long distance transport. It is known that such transport was taking place; for example, Aiston mentioned (1934) that some grinding stones were transported from Anna Creek to Mungaranie - about 270 km in a straight line across Lake Eyre, and about 400 km around the lake (compare McBryde 1987, 1992).

for grinding. Hammerstones are predominantly made of quartzite. The rare examples of silcrete and quartz hammerstones that I observed on the mound springs are scarcely represented in our sample (silcrete 1; quartz 0). An explanation of this preference for quartzite hammerstones should include the average flaking property of quartzite, its size, and availability of quartzite pebbles almost everywhere (except vicinity of site ST).

TOOLS AS A REFLECTION OF SUPPLY AND DEMAND

Figure 50 (p.223) shows the relationship between raw materials, all tools and major categories of formal tools (six sites are only included). In summary it is worth noticing some outstanding examples of frequency of raw materials and relative frequency of specific tools.

Site A is dominated by quartz but the largest numbers of tools, scrapers and retouched flakes are made of silcrete.

Site B is dominated by quartz but nearly half of all scrapers are made of silcrete.

Site E is dominated by quartzite but nearly half of all scrapers are made of chert.

Site G is dominated by quartzite but chert comprises the largest group of scrapers and most of tulas are also made of chert.

Site H is dominated by silcrete but about half of the cores are made of quartz and the largest group of scrapers are made of chert.

Site ST is dominated by silcrete but half of the microliths are made of quartzite.[9]

This pattern provides important evidence demonstrating that

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[9]. Dan Witter expressed his disbelief (pers. com. 1990) that such a large proportion of backed blades (but only small quantity in total) are made of quartzite despite the dominance of silcrete at site ST. He made me aware that some silcrete can be very similar to quartzite. On the other hand mineralogist Ross Pogson (Australian Museum) confirmed my classification of raw materials (pers. comm. 1989). However, if some silcrete is miss-classified as quartzite and it has more quartzite-like flaking property and coarse texture, this fine distinction between raw materials may be unimportant. It must be noted that all four materials encountered in this study display very distinctive differences with the most similar material being very fine silcrete and local, poor quality chert.

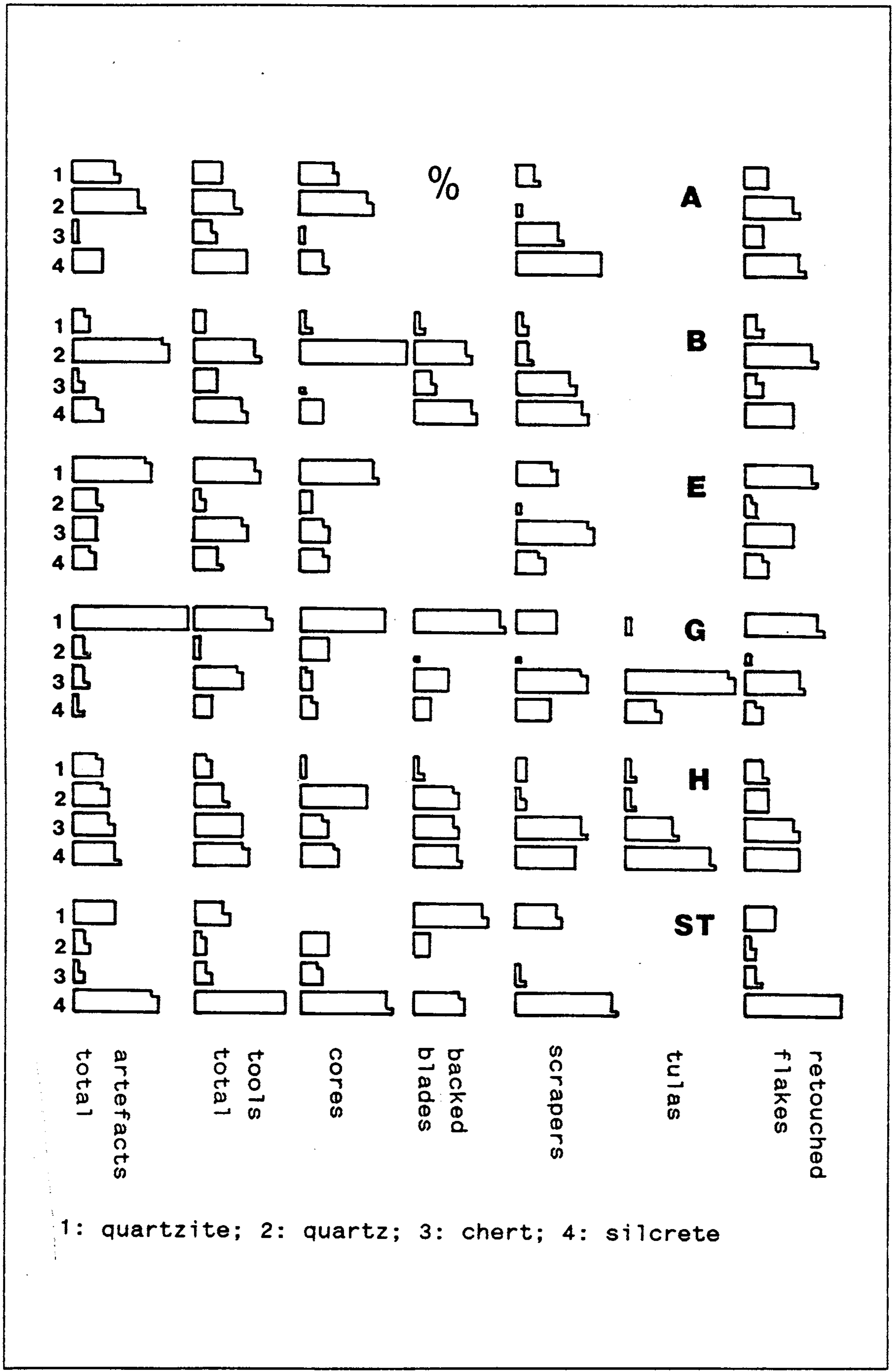

Figure 50. Relationship between tools and raw materials (%), by aeesmblage.

assemblage structure is affected by both supply and demand. It is clear that sometimes conflict between supply and demand can be resolved by compromise. This can be inferred from the substitution of desirable material by second best or only just acceptable, locally available material. For example the preferred materials for backed blades are quartz and silcrete, however on site G where quartz and silcrete are rare, 61% of backed blades are made of locally abundant quartzite. A more extreme example is provided by scrapers on site B. This site is dominated by quartz while the other three types of raw material suitable for scrapers are relatively rare. Faced with a supply so unfavourable for the production of scrapers, the inhabitants attempted to use quartz scrapers which comprise a surprisingly high proportion, nearly 10%, of the total.

In other situations the conflict between supply and demand cannot be resolved and desirable material must have been brought to the site for specific tools. This supplementing of local material with types of stone desired for specific implements can be illustrated by the following examples. On site A where chert is very rare, 20% of this material was used for retouched flakes and scrapers (33% by weight). On site B where chert is equally rare 11% of it was used for retouched flakes and scrapers (23% by weight). A similar situation occurs on site G where chert scrapers, retouched flakes and tulas make up 10% (34% by weight) of total. This ratio of selected tools to total amount of chert is much higher than the average ratio of tools to raw materials (5%). This reinforces the supposition that non-local material such as chert has been procured and transported from far away for a specific purpose, that is mainly for tools such as scrapers, tulas and retouched flakes, to work with hard wood.

6. Relative frequency of tools

Scrapers and retouched flakes

Figure 41 (p.214) shows the relative frequency of tool types among the assemblages. It is evident that retouched flakes, scrapers and cores combined make up the largest number of the tools on the sites (84.8% mean for eight sites) while retouched flakes and scrapers together account for 63.5% of the tools.

In the preceding chapter I discussed briefly the functional relation between retouched flakes and scrapers. I suggested that in functional terms retouched flakes and scrapers are not exclusive but represent a continuous range of tools. The lower section of this spectrum is defined by incidental use, low degree of modification and higher discard rate (retouched flakes). The upper section is defined by repetitive use, intensive modification, and relatively lower rate of discard (scrapers).

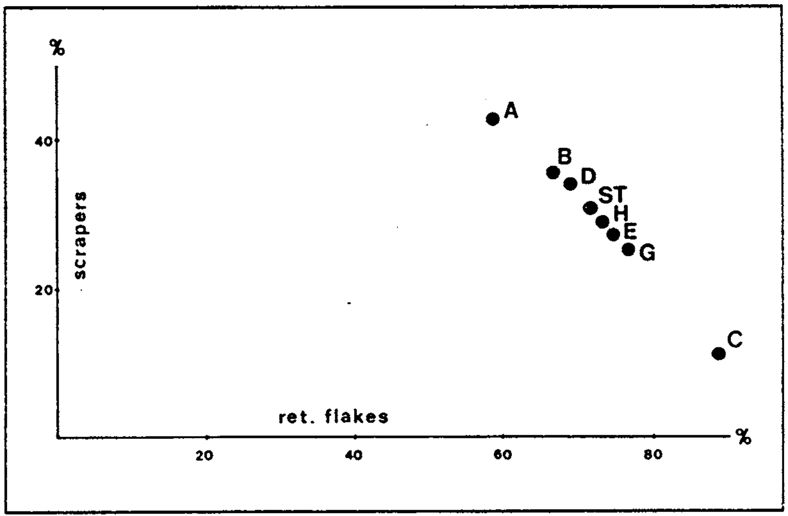

Figure 51. Relative frequency of retouched flakes and scrapers, by assemblage.

In the broad sense scrapers are retouched flakes, however more formalised by repetitive use and edge maintenance. The evidence supporting this claim can only be circumstantial. There are three sets of evidence: a) scrapers are smaller than retouched flakes within same assemblage and type of raw material; b) scrapers are distinctively shorter than retouched flakes within same assemblage and type of raw material, and; c) in relatively large sample there is usually a portion of tools that appear to be an intermediate stage between retouched flakes and scrapers.

If there is such a relationship between retouched flakes and scrapers the former can be seen as more casual, expedient and unspecialised implements, while the latter can be viewed as more specific, curated, and specialised tools. In accordance with this, assemblages with a relatively high proportion of scrapers reflect more consistent and/or specialised craft-work than assemblages characterised by lower proportion of scrapers.

Figure 51 demonstrates the relative frequency between scrapers and retouched flakes at each site. It must be mentioned that retouched flakes are always more common than scrapers on habitation sites and for two groups of tools combined 25-35% of

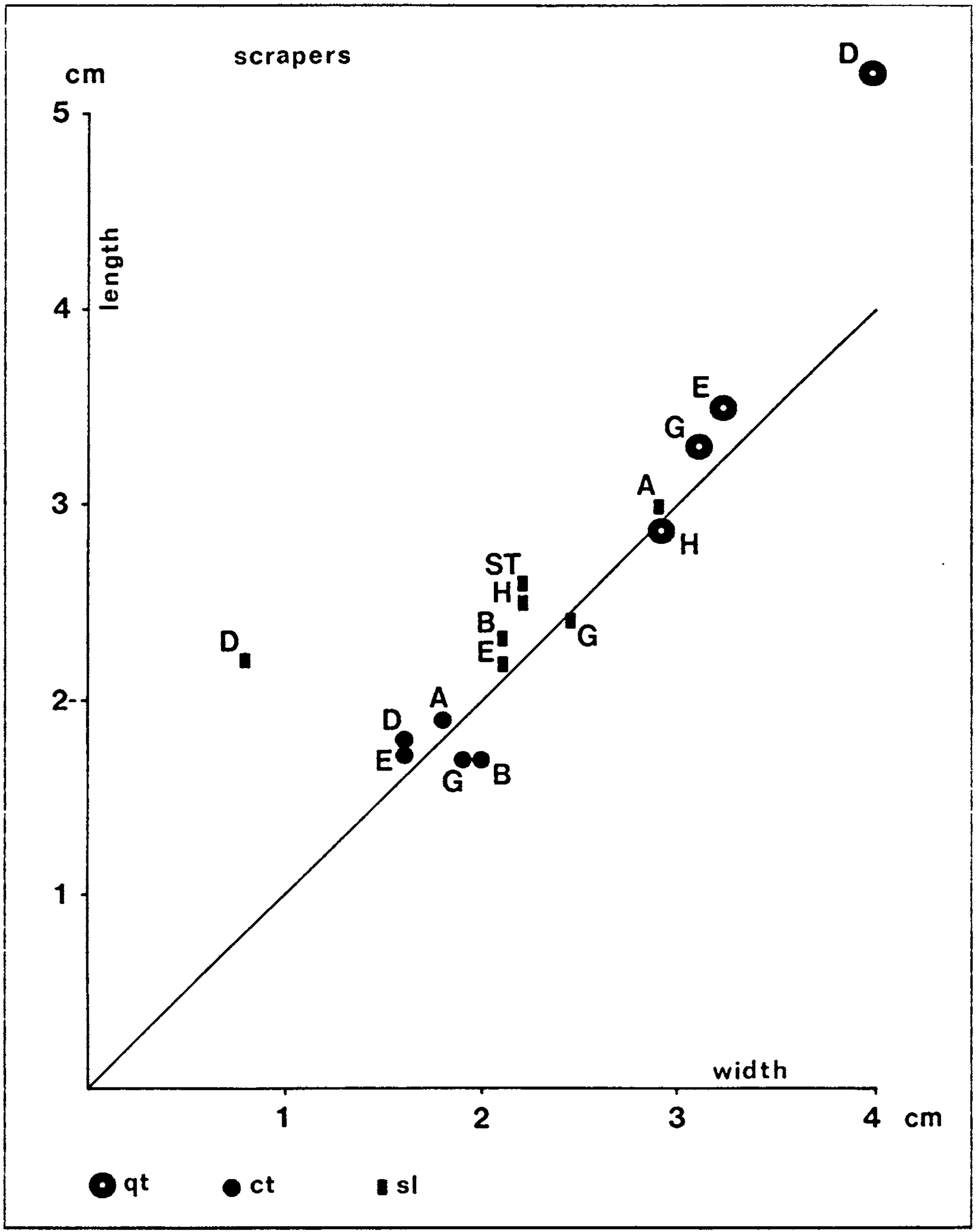

Figure 52. Relationship between length and width of scrapers by raw material, within assemblages, middle line represents length/width ratio of 1 : 1.

scrapers can be considered a standard on the mound spring sites. On site C there is only 11% of scrapers against 89% of retouched flakes. This site seems to be characterised by transient or otherwise short camping episodes where craft-work has been largely a more casual and impromptu activity. In contrast, on sites where camping episodes were of longer duration craft-work has been a more systematic and regular activity which is documented by a comparatively higher proportion of scrapers and lower proportion of retouched flakes.

This point can be taken even further if we argue that size and type of raw material somehow reflects the precision and intensity involved in work with respective scrapers.

First of all we need to look at the general pattern of size and distribution of scrapers between raw materials. Quartz scrapers are poorly developed and so rare that they should be seen as improvised implements made from material basically not suitable for the intended job. Consequently we will consider only quartzite, chert, and silcrete scrapers.

Quartzite scrapers are the largest and their morphology implies a function comparable to a coarse rasp. The average quartzite scraper is 4.1 cm long and 3.4 cm wide.

Silcrete scrapers usually made of fine grained material, are better developed by more retouch and considerably smaller, 2.4 cm long and 2.3 cm wide.

Scrapers made of chert are smallest and they are suitable for tasks demanding precision and best quality craft-work. They are 1.7 cm long and 1.8 cm wide.

Although there is a virtual lack of blade technology among the mound spring assemblages many scrapers are made on slightly elongated flakes. Length reduction seems to indicate repetitive resharpening and by inference more intensive and curated use of a tool. In the sample of 146 chert scrapers the mean length of tools is slightly shorter than their width. In contrast the average silcrete scraper (sample 167) is slightly longer than its width while the average quartzite scraper (sample 102) is visibly longer in relation to its width (Table 25: complete specimens are only included).

Table 25: scrapers

raw material	mean weight (g)	mean length (cm)	mean width (cm)	N
qt	24.9	4.1	3.4	102
ct	2.0	1.7	1.8	146
sl	5.9	2.4	2.3	167

While size differences reflect overall distinctions between scrapers made of three types of raw material, variability between the sites demonstrates the reduction of scrapers and by inference the intensity of their use. Figure 52 (p.226) shows scrapers of different raw materials plotted according to their length and width.

Chert scrapers on site A are almost as long as they are wide. On sites D and E they are slightly longer in relation to their width, while on sites G and B the length is most visibly reduced. Larger silcrete scrapers tend to be elongated and only on site G are length and width equal. Quartzite scrapers, except for site H, are clearly elongated. In a somewhat simplistic way scrapers shorter than their width (under the line representing equal length and width) reflect intensive usage; while elongated scrapers (above the line) reflect less intensely used implements.

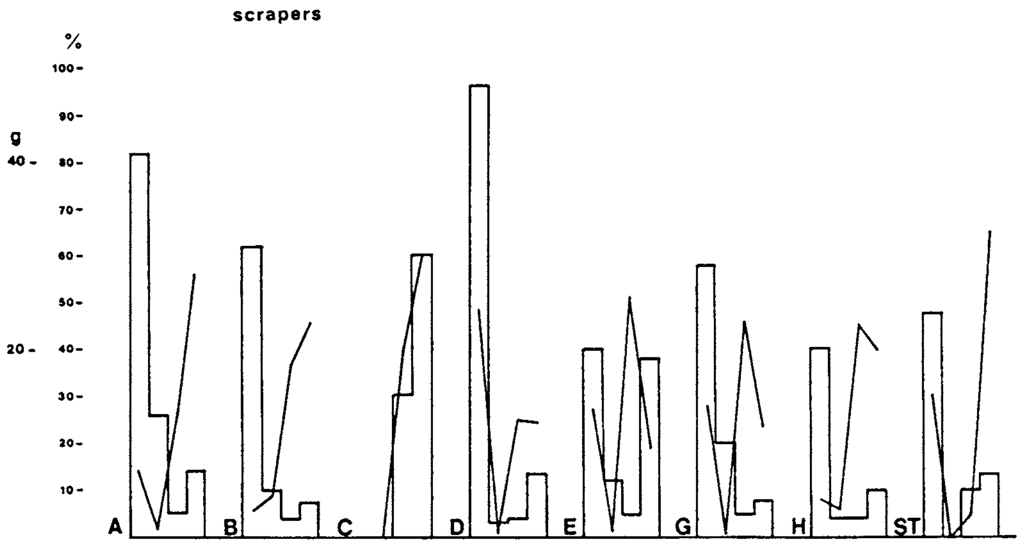

Figure 53. Mean weight (bars) and relative frequency of scrapers (lines) within assemblages.

In order to analyse these variables more systematically in the sites' context I plotted the mean weight of all scrapers (broken specimens included) and their relative frequencies for eight assemblages (Fig. 53). According to my hypothesis the least intensive and systematic woodcraft can be inferred from the highest proportion of large quartzite scrapers. In contrast the most systematic and intensive woodcraft may be inferred from a high proportion of small chert and silcrete scrapers.[10]

Site D illustrates the first instance, where quartzite scrapers are heavy on average (48.1 g) and account for 48% of all scrapers. Located nearby, site E is characterised by much smaller quartzite scrapers (19.9 g) which make up only 27% of the total while light chert scrapers (2.5 g) constitute 51%.

Site C illustrates another extreme where the silcrete scrapers are heavy (30.5 g) and most common (60%) and chert scrapers are also exceptionally heavy (15.0 g)[11] accounting for nearly 30% of the total.

Figure 54 shows scrapers of three types of raw material plotted according to their weight and relative frequency. All heavy scrapers are grouped in the central and right sections of the diagram. All quartzite scrapers are present here; they are abundant on site D and rare on sites B and H. Two samples of silcrete scrapers are also present in this group; they are abundant on site C and moderately frequent on site E. One sample of chert, characterised by exceptionally heavy scrapers, seems to gravitate towards this group and it represents site C.

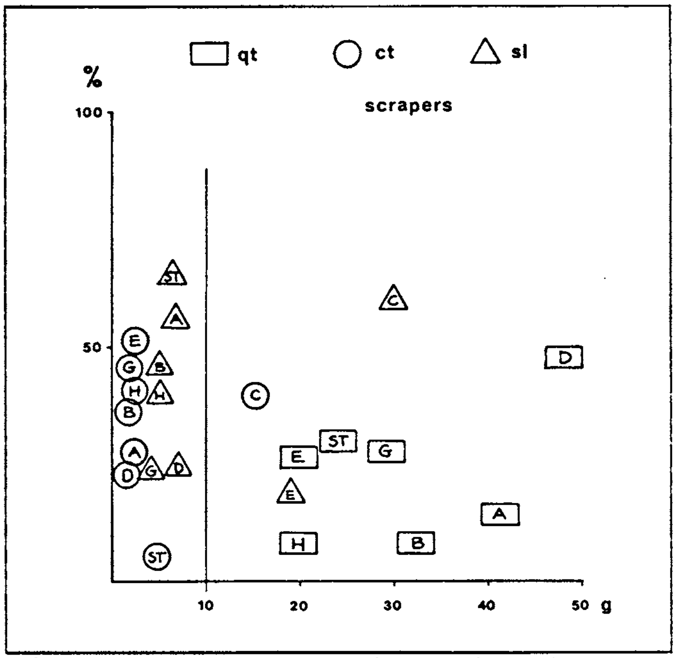

Figure 54. Mean weight (horizontal axis) and relative frequencies (vertical axis) of scrapers by raw material within assemblages.

All light-weight scrapers (under 10g) are concentrated in the left section of the diagram. Chert scrapers are the least

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[10]. This hypothesis can be supported by ethnographic observations, for example in relation to the adzing tools Roth (1897:101) noted that "the larger variety of the native-gouge is rather for 'cutting in the rough', the smaller more for 'finishing off.'"

[11]. Chert scrapers on site C (although not numerous) may represent possibly early stages of use (15g). In comparison to other sites (2.7g mean for seven sites) it indicates how much these scrapers are usually reduced (about 12.3g).

variable ranging from about 2 g to 5 g and they are abundant on sites E, G, H, and B, but infrequent on sites D and ST. Small silcrete scrapers show little variability ranging from 4 g to 7g and they are abundant on sites ST and A while far less frequent on sites G and D.

To summarise this analysis and compare scrapers to retouched flakes I plotted all scrapers and all retouched flakes for every site by weight and relative frequency (against all tools). Figure 55 shows the distribution of scrapers (all below 30% of all tools) and retouched flakes (all above 30% of all tools). Sites B and H are characterised by smallest scrapers, sites G, E, ST and A by medium size and sites D and C by the largest scrapers. The frequency of scrapers on site C is extremely low.

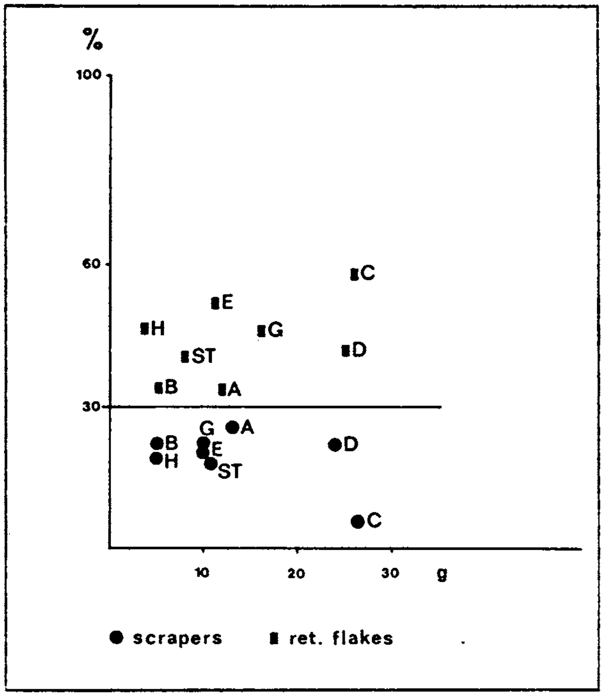

Figure 55. Mean weight (horizontal axis) and relative frequency (vertical axis) of scrapers and retouched flakes.

With two exceptions (sites G and ST), the distribution of retouched flakes shows almost a mirror image of scrapers. For example, site C is characterised by small portion of scrapers and large portion of retouched flakes, both about the same weight. In contrast site A displays a large proportion of scrapers and relatively low proportion of retouched flakes. Such similarity of size between retouched flakes and scrapers (even for all raw materials combined) and the evident pattern in their relative frequency provides additional support for the assumption that these tools are related by function and common origin - that is development through use and resharpening.

TULA

In functional terms the tula is closely related to retouched flakes and scrapers. The tula is the most specialised woodworking tool. It is often referred to as an adze because of its use known from ethnographic records. However a tula is not related to the retouched flakes or scrapers by common origin; unlike a scraper it is not developed from ordinary flakes by use and resharpening. Tula adzes are made from specific tula flakes which are produced by a particular, specialised flaking technique.

Table 26: tula (numbers within sample and % of total tools)

site	A	B	C	D	E	G	H	ST
n	4	16	1	5	7	32	21	11
%	2.2	2.4	1.4	1.1	1.3	5.0	3.5	10.0

The small sample of tula adzes prevents an elaborate analysis. In terms of relative frequency tulas constitute 10% of the tools on site ST and 5% on site G. In contrast tulas make up only a tiny portion of tools on site C (Table 26). This pattern can be easily explained in terms of what we have already learned about the structure of the assemblages and raw material supply associated with particular sites. Distance from any material suitable for flaking (site ST) implies a tendency towards curated tools (eg. high proportion of scrapers in relation to retouched flakes, see Fig. 51, p.225). It seems that the cost of transporting raw material was an inducement to bring and use the most efficient and long-lasting tools such as tulas. On site C, which appears to be a transient campsite, tools associated with systematic craft-work are infrequent and the minute proportion of tulas fits neatly into this pattern.

It is of interest to note that scrapers and retouched flakes form the universal tool component on habitation sites. On the mound spring campsites this group makes up a very stable proportion of the tools accounting for 63.5% (mean for eight sites) with standard deviation 3.83. Scrapers, retouched flakes and tulas combined account for 66.8% of tools with an even lower standard deviation 3.50 (Fig. 56, p.232). Other tools should be analysed in this context with the understanding that they constitute only a small, and far more variable proportion of tools in the assemblages.

BACKED BLADES

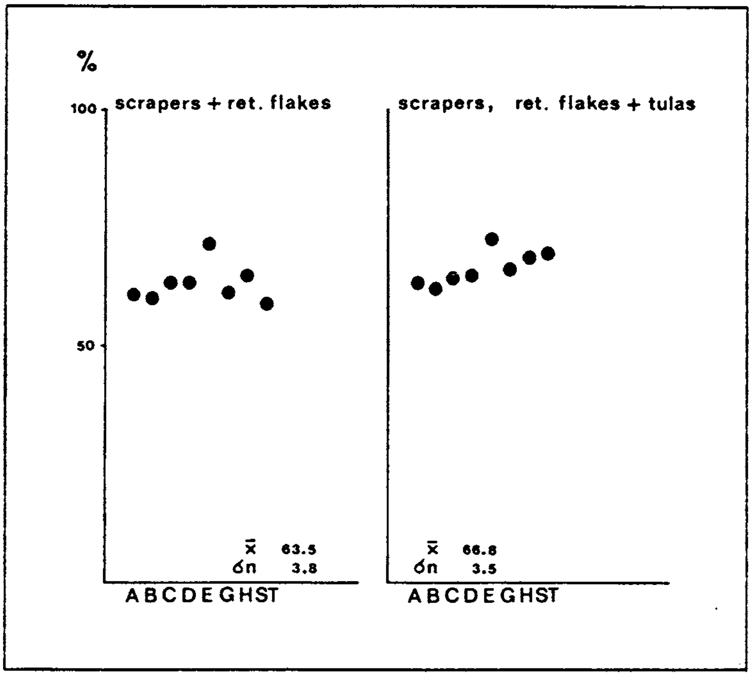

Figure 56. Frequency of scrapers and retouched flakes (left) and scrapers, retouched flakes, and tulas (right) within tools.

Table 27: backed blades (numbers within sample and % of total tools)

site	A	B	C	D	E	G	H	ST
n	5	108	7	4	23	65	60	8
%	2.7	16.2	9.8	0.9	4.4	10.3	10.0	7.3

Backed blades on the mound spring sites are exclusively geometrics of crescentic and triangular shape. Several backed blades are shaped less carefully and they look like forms intermediate between crescent and triangle. Table 27 shows the distribution of geometrics.

In light of the foregoing discussion we can assume that backed blades are a kind of cutting implement. The distribution of backed blades is intriguing. On site G, containing a relatively high proportion of backed blades, 61.5% are made of local quartzite.

A similar pattern can be seen on site C where about 70% of these implements are made of local silcrete. On site H, 95% of backed blades are made of local quartz, chert and silcrete (in almost equal proportions). Such an association between tools and raw material suggests that high frequency is related to on-site production. However on site B, characterised by the highest proportion of backed blades among tools, 42.5% are made of a relatively infrequent material - silcrete, while the second largest proportion, 37.9%, is made of local quartz. On site ST half of the backed blades are made of the less preferred material - quartzite and the remaining half of the more preferred quartz and silcrete.

Sites B, G, H and ST are characterised by intensive craft-work and a large proportion of backed blades can be associated with such activity. However, craft-work was the least intensive or systematic on site C where backed blades are relatively frequent (about 9.8%). This suggests that the frequency of backed blades may reflect two factors: a) local manufacturing, and; b) retooling.

At this stage it is only speculation that assemblage C may reflect a component of hunting activities. This speculative argument must consider that on site C, manufacturing and possibly retooling of some implements took place. Since most backed blades are made of local silcrete, on-site manufacturing is suggested (if only a small quantity). If there was any urgency of such manufacture it may be because of the necessity for retooling. The most likely implements that may require urgent retooling on a transient campsite are hunting tools or weapons.

If we accept such an explanation it may be assumed that a large proportion of backed blades on other sites also reflect possible hunting (or more specifically retooling) activity. In this context it may be of interest to note that sites G, B, H, and ST contain visible quantities of animal bones. These bones are highly fragmented and they disintegrate rapidly in the local environment. For this reason it is difficult, if not impossible, to attempt any elaborate study of the association between types of tools and faunal material. However a virtual lack of animal bones on site C can lend support to the suggestion that on longer occupied sites G, B, H and ST both retooling and game consumption took place. Although retooling may have taken place on site C, game appears not to have been transported back to the site for consumption. Such a custom would be consistent with a highly mobile life strategy practiced during occasional departures from the springs.

HAMMERSTONES AND GRINDING STONES.

Hammerstones and grinding tools present a problem for analysis. In statistical terms they constitute a tiny portion of the assemblages. As implements targeted by amateur collectors they are likely to be a far less reliable indication of assemblage structure. Any breakage or removal of these implements that occurred after contact can drastically alter the statistical picture of an assemblage.

For instance, in the sample from site D three grinding stones were recorded. The first is a complete grinding base, the second is a base fragment, and the third is a section of grinding base broken (probably recently) into several small pieces. If all these fragments are counted (35) site D would be characterised by the highest relative frequency of grinding stones. This would be contrary to on-site observations which suggest that both complete specimens and fragments are very infrequent on the site. On the other hand small fragments document the presence of grinding stones even when complete specimens have been removed by collectors (hence the necessity to quantify fragments). These small fragments of grinding stones found in the samples suggest that even broken and discarded stones were commonly recycled, often beyond recognition (eg. Aiston 1934:2). Because this recycling process ceased after the sites were abandoned by their inhabitants, recently broken grinding stones tend to increase the number of fragments to an exceptionally high level.

Both hammerstones and grinding stones underwent a peculiar process of reduction. Hammerstones must, sooner or later, be broken. Such broken fragments were usually discarded. However in some circumstances (eg. site ST) they can be reused in the form of heat retainers, ultimately causing further breakage and often complete annihilation of identifiable pieces of the original implement.

Over time grinding stones became worn out and eventually they tended to break up into small pieces. The number of complete grinding implements may reflect roughly actual site use (eg. number of households customarily using the site at the same time and/or in alternate manner[12]) and short term expectations concerning future site use by the provision of new grinding bases which must be brought from specific distant locations. In the long term of repetitive site occupation, fragments of grinding implements (especially relatively rare sandstone) are intensely recycled. With time many fragments disappear completely from an assemblage. It seems that the cumulative effect of discarded fragments decreases with the passage of time, reflecting only the most recent stages of site use rather than its whole occupation. If this is true it may be reasonable to speculate that a relatively high proportion of grinding stones is likely to be due to the rapid dune build up which covered many these fragments in the period of site use (eg. sites G and ST) rather than to the exceptional importance of grinding at the site.

In short, complete grinding bases do not reflect the cumulative effect of site occupation but may provide a rough picture of site population within a short timespan (eg. several years). Small fragments of grinding stones may reflect the component of grinding activities customarily performed on site over the longer period but their accumulation seems to be truncated with the passage of time. Consequently cumulative amounts of flakes and fragments of grinding stones cannot be compared because the former appear to be a stable, long surviving component of assemblages (with tendency to proliferate by breakage) while the latter must be considered as 'perishable'.

In order to level out some of the adverse circumstances related to representation of hammerstones and grinding tools I used original raw counts to calculate the number of implements per 1000 stone artefacts as well as their percentage of total tools in every sample (Tables 28 and 29, p.236).

Although these data are the most difficult to handle it seems that the pattern of high and low frequency fits other characteristics of assemblages. For instance, site A, characterised by a large proportion of cores, shows a large

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[12]. A single grinding slab and a hand-stone may indicate the presence of a woman and/or family household (eg. Peterson 1968:569). However ethno-archaeological study in Western Desert shows that such a relationship in open campsites is unreliable (Nicholson and Cane 1991:340).

Table 28: hammerstones

site	A	B	C	D	E	G	H	ST
n	4	3	2	7	4	26	7	1
a	1.5	0.2	0.7	0.8	0.3	1.4	0.6	0.3
b	2.2	0.4	2.8	1.6	0.7	1.1	1.1	0.9

-a - per 1000 stone artefacts; b - % within total tools

Table 29: grinding stones

site	A	B	C	D	E	G	H	ST
n	1	7	0	3	5	31	3	8
a	0.3	0.6	-	0.3	0.6	1.6	0.2	3.0
b	0.5	1.0	-	0.6	0.9	4.9	0.5	7.3

-a - per 1000 stone artefacts; b - % within total tools

component of hammerstones. Outstanding for its primary flaking and intensive reduction, site G also shows a large component of hammerstones.

Smaller components of hammerstones are characteristic for sites B and E where only quartz has been flaked. A comparatively small component of hammerstones on site ST may be due to intensive recycling.

Sites C and D present an interesting case where hammerstones seem to fit the overall robust size of artefacts rather than with assemblage structure. Both assemblages are characterised by little flaking and low degree of reduction. It should be remembered that hammerstones may not be related to flaking only. Credible examples of other uses of hammerstone are: a) breaking animal bones (eg. site G); b) breaking blocks of conglomerate to obtain quartz pebbles (eg. site A), and; c) extracting pieces of ochre from porous sandstone (eg. site G). Other activities such as breaking nutshells or crushing plant fibres should produce different, distinctive use-wear typical of pounding stones. However hammerstones are not specialised for one task only and a short episode of flaking can leave more prominent use-wear than short-duration work with soft material.

Grinding stones cannot be exclusively related to seed processing. Some small fragments are especially difficult to classify in this respect. However in order to avoid attempting fine functional distinctions I assume that a substantial portion of grinding stones could have been used for processing hard food derived from plants.

Assemblages ST and G show large components of grinding tools and it can be inferred that seed processing played an important role on these sites. Alternatively, this can mean only that dune development overlapped in time with human occupation, contributing to burial and thus better preservation of small fragments of grinding stones than on other mound spring campsites.

The virtual lack of grinding tools on site C is easy to explain by the transient nature of camping episodes associated with this site.[13]

Sites B and E contain moderate amounts of grinding stones. Other sites contain only minute components of this implement. It can be assumed that less than 10 fragments of grinding stone per every 1000 stone tools is a reasonable standard on the mound spring sites.

I suspect that complete grinding dishes have been removed by collectors from many mound spring sites.

7. Summary : raw materials, tools and sites

Evidence produced in this chapter demonstrates several aspects of variability among the mound spring sites. In this section I will summarise these variables within three groups: raw material, artefacts, and assemblages.

The purpose of this summary is not only to integrate different aspects of variability but also to outline the characteristics of the individual mound spring campsites.

RAW MATERIAL

The four types of stone commonly used on the mound spring

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[13]. I noted one fragment of grinding base on site C (outside the sampling area).

campsites are distinctively different. These differences manifest themselves in flaking properties, sharpness of flake edges, texture, suitability for different tasks (eg. cutting, adzing) and resharpening. Also there is a difference in size of raw material (eg. quartzite versus quartz) and geographical distribution.

Quartzite

Quartzite is very common in the mound spring country. On the whole it comprises the largest component of stone paving a gibber plain, but it can also be found in outcrops (eg. near site G). It can often be found in pebbles the size of an emu egg on the surface or as far larger blocks in an outcrop. Quartzite represents an average flaking property and with its usual coarse texture, moderately sharp flakes. It is the best material for heavy tools such as hammerstones and anvils. Large uni- or bifacially flaked pebble tools (none found on the habitation sites but observed commonly in the off-site context) and heavy cores are good for chopping wood (eg. Hayden 1976, 1979a), and quartzite scrapers are good for rough woodwork and probably other soft organic material. Quartzite is not so good for precision work in hard wood or bone due to its coarse texture.

Quartzite is associated with large artefacts (almost exclusively the material for hammerstones), and is the third (and practically least) preferred material for scrapers. Quartzite scrapers are most elongated and by inference least intensely used. It has however been generously used for retouched flakes where locally available (sites D, E, and G).

In spite of being so common quartzite has been consistently flaked on only two sites, G located near a quartzite outcrop and site ST, where there is no local material for flaking. Such flaking on site G visibly comprises preparatory and primary flaking. In contrast, on site ST only primary flaking and further intense reduction of quartzite took place.

Because of the relatively large proportion of quartzite (28%) on site ST it may be assumed that there was demand for larger tools typically associated with quartzite. Such tools are large scrapers (30%), large retouched flakes (20%), and top (grinding) stones (62%) of respective tool categories.

In cases where quartzite was locally available but not localised (eg. in an outcrop) it was reduced off-site. Production of blanks, preparation of cores and their partial exploitation was taking place in the sites' vicinity (sites D, E and H). On site B partial exploitation of quartzite cores may have taken place within the site periphery.

Quartz

Quartz is a common material in the mound spring country but far less so than quartzite.[14] Typically quartz pebbles, rarely exceeding the size of a chicken-egg, are scattered in a roughly uniform manner over the gibber plain. Although there may be some small outcrops of quartz in the area, the only 'quarrying' of this material that I know of is associated with site A at the Welcome Springs. This material, especially when derived from the quarry, must have been valued judging by its extensive use on site A and B.

On the whole quartz in this area shows average to poor flaking property. Some pebbles collected from the surface break into pieces (shatter) when flaking is attempted. Other pebbles can be partially flaked producing a high shatter/flake ratio. Pebbles of better quality can be flaked well with a hard hammer producing numerous thin flakes with very sharp edges. It is likely that quartz was sought especially for its sharp flakes (eg. backed blades). As a material unsuitable for retouching quartz is not well represented among formal tools which are largely defined by retouch. However both quartz cores and flakes are found on every site in reasonable quantity.

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[14]. I quantified a small sample of stone material on the gibber plain near Davenport Springs, counting and weighing all pebbles equal to and larger than a walnut. On 1m^2 there are 361 pebbles of quartzite, 10 pebbles of quartz and 10 of silcrete (94.7%, 2.6% and 2.6% respectively). Quartzite accounts for 56.25 kg, quartz for 1.1 kg and silcrete for 0.7 kg (96.8%, 2% and 1.3% respectively). Although there are limited areas where quartz is slightly more frequent and some where silcrete accounts for nearly one third of material (and still more near silcrete outcrops) these data provide a rough picture of disproportion where quartzite is the most dominant material.

Except for site A quartz has always been flaked on-site, suggesting its universal use as instant cutting implements. Small cores providing relatively large amounts of small sharp flakes offered a visible cost incentive to bring quartz pebbles into a campsite and flake them when needed. Quartz is associated with small artefacts and its high frequency in an assemblage may reflect an aspect of economising on the cost of transport (eg. quartz scrapers on site B).

Quartz is only moderately represented (10%) on site ST, distant from any sources of stone for flaking. This may suggest that quartz was even less common in the areas closest to this site. However, a more likely explanation is that quartz, despite its value as sharp cutting flakes, was unable to fulfil other demands.

Chert

Although chert can be found in the area it is of poor quality. I found an outcrop where chert pebbles rarely reach the size of a grapefruit. There must been a local source of chert near site H but I could not locate it. My impression is that good quality chert in the form of large blocks or pebbles is rare, if not absent in the mound spring country. In either case chert can be considered as non-local material.

Chert displays good flaking properties and it is hard with flakes of sharp edges. Cores are infrequent suggesting intensive use of this material and high cost of its acquisition. Chert is good for trimming and repetitive retouching and therefore is often associated with the smallest artefacts and with curated implements such as tulas and small scrapers. The fact that about half of the tula adzes in the sample are made of the second best material, that is, a local silcrete, supports the assumption that chert of good quality and required size was not available locally. Chert appears the most desired material to use on hard wood and therefore a high proportion of small chert scrapers and tulas in any assemblage indicates intensive woodcraft.

Intensive reduction and recycling of chert artefacts as reflected in the mean low weight and small proportion of cores must be attributed to three following factors: a) a high value for woodcraft; b) a high cost of procurement and transport, and;

c) the inherent properties permitting repetitive trimming, modification and reuse.

In ethnographic contexts chert is known to undergo thermal treatment to improve its flaking properties. Most of the material reduced on the mound spring sites appears to be flaked with a soft hammer or intermediate tool resulting in greater precision and less waste by-products. Such flaking also indicates the high value attached to chert as a raw material.

Silcrete

Silcrete is a common material in the mound spring country but its distribution is patchy. Numerous outcrops of silcrete are present in the western part of the study area but they are less frequent in its eastern part. Silcrete displays great variety: its texture ranges from very fine and smooth, resembling chert, to coarse grained and rough. Silcrete comes in different sizes from small and medium size pebbles found on gibber plains, to large blocks in the outcrops. Regardless of texture its flaking properties are better than those of quartzite. This makes silcrete less suitable for abrasion as it tends to shatter when under mechanical stress.

Consequently the average silcrete pebbles in the gibber plain are far smaller than quartzite pebbles. For this reason a gibber plain is an unlikely source of good quality silcrete required for flaking. Silcrete can shatter profusely when in thermal stress and therefore is not the best material for heat-retainers or cooking stones (compare Tunbridge and Culthard 1985:19).

Silcrete produces flakes with sharp edges but it is also suitable for repetitive retouching and edge maintenance. Therefore it is a desired material for sharp cutting implements and good material for woodworking tools such as small scrapers and tulas. A high proportion of small silcrete scrapers and tulas in an assemblage can be read as a signature of intensive woodcraft. This material is also suitable for large implements such as choppers (totally absent from habitation sites) and large core tools (presumably used for chopping).

It must be understood that despite being the common local material, silcrete of useable quality is generally limited to specific outcrops. From this point of view the availability of silcrete is somewhat restricted. While it is present within the vicinity of some sites (eg. sites C and H) it is rare in other areas (eg. sites D, E and G). Such distribution has an obvious influence on raw material economy. For example, where silcrete is easily available there is a sharply diminished demand for quartzite (eg. sites C and H). Silcrete has been flaked intensively only on two sites, G and ST, to which it was transported from distant outcrops (about 10 km).

Economy of raw materials

Variation in the use of raw materials must be seen in the light of supply and suitability for specific applications. For example in many respects quartzite cannot be substituted for quartz or chert but it may be substituted for by silcrete. Similarly chert cannot be substituted for by quartzite or quartz but can be substituted for by silcrete.

Although quartz in its universal cutting role can be substituted for by all other types of raw material it is distinctive for its sharp flakes and is widely spread in the area. Quartzite is far more common than quartz but is not equally sharp and is much heavier to transport. It appears that for these reasons quartz pebbles were always transported to a site for subsequent flaking providing a ready supply for instant cutting implements. In contrast, quartzite was flaked intensively on only two sites, site G located near a quartzite outcrop and site ST away from any sources of material for flaking.

While in local supply silcrete was utilised for a variety of tools from cutting implements and retouched flakes to scrapers and backed blades. When transported from outcrops silcrete has been used more specifically for curated tools such as small scrapers and tulas while the role of large tools was assumed by locally available quartzite.

These four types of raw material with differences in quality, properties, size and distribution make up the fairly complex supply structure in the region. The local subsistence economy utilised all these types of stone in complex ways. We can see quite clear associations between types of stone and different categories of tool. Within individual assemblages such associations can be modified by replacing better material with a less costly one. However, it is clear that demand in the area of lithic raw material was stimulated by other needs which constitute a core of subsistence economy and involve procurement of food, other organic materials, and tasks from food processing to craft-work. Although my analysis provides several clues to regional economy I will not attempt to paint a picture similar to ethnographic reality.

CAMPSITES

Site A

Site A is in many respects a peculiar campsite. A medium density of scatter, along with frequency and variety of craft tools (especially scrapers), demonstrates its habitation character. On the other hand, the proportion of cores and hammerstones is well above average but there is little evidence of on-site flaking (indicated by small proportion of small flakes). This evidence suggests that flaking was crude (eg. preparatory) and unsystematic with a relatively high proportion of large flakes, high frequency of cortical flakes (quartzite and quartz) and heavy "shatter" (quartzite, quartz and silcrete). Such a pattern can be expected from initial preparation of cores and initial modification of artefacts (other than flakes).

Although it is difficult to point to a specific signature within the assemblage structure, this pattern is also compatible with extracting quartz pebbles from local conglomerate. Residual gibber plain material which is present on the site in the form of pebbles (mostly quartzite) seems to be utilised as impromptu anvils and hammerstones. This in turn contributed to the generous discard of hammerstones and high rate of heavy "shatter".

Taking into account typical spacing between dwellings in arid Australia quoted by various sources (O'Connell 1987; Nicholson and Cane 1991) this site could have accommodated only two or three households at a time but would be far more comfortable for one. In contrast to nearby site B, this site provided far better shelter and a view over a large section of the Welcome Springs valley.

Site B

Site B with a high density scatter and many small artefacts is a very good example of a habitation site. The range of craft tools such as scrapers made from different materials, tulas and retouched flakes indicates its habitation character. The same conclusion can be drawn from the large number of fireplaces and the presence of animal bones on the site. A high frequency of intensely reduced scrapers (chert and silcrete) indicate that woodcraft was a common activity. A relatively high proportion of backed blades suggest the manufacture and retooling of hunting equipment. The inhabitants were making the best use of locally available material and this tendency is well demonstrated by the use of quartz scrapers.

Local quartz has been consistently flaked within the site but the technique that results in the production of bipolar flakes is absent. This fact supports the view that quartz flaking was often a simple instant reduction of small, locally acquired cores to obtain immediate cutting implements.

Site C

Site C is located away from the springs (15 km from the closest springs) at a rockhole which retains water for some weeks after rain (perhaps even for several months during mild climatic conditions). Silcrete outcrops are present in the vicinity of the rockhole. This silcrete has been quarried here and knapped in a specialised workshop for regular long blades. The bulk of stone artefacts on site C has been evidently collected from knapping floors scattered over the area.

Site C is distinctive for its low density scatter, large artefacts, and small proportion of tools (2.6% of all artefacts). These features suggest a low intensity of occupation and minimal amount of flaking performed on the site. The only material consistently flaked within the site was quartz, although in a small quantity. Silcrete was universally used for nearly all tasks where stone implements were required. In the sample of 2655 artefacts quartzite (common in the area) accounts for only 32 flakes and one hammerstone. In contrast chert is represented by nearly one hundred flakes and a handful of tools including scrapers and tulas.

The assemblage is characterised by a large proportion of retouched flakes and a small quantity of scrapers suggesting that craft-work was of little importance. Such a pattern is distinctive for sites associated with transient camping during highly mobile exploitation of back country away from the springs. This inference is reinforced by the fact that unlike any other site, here backed blades are more common than scrapers. With 1.4 backed blades for every scraper, site C provides a strong contrast to site B where backed blades are the most frequent (16.2% of tools) but there is only 0.7 backed blades per scraper. Despite the fact that backed blades are not numerous (along with other tools) it seems reasonable to assume that retooling of hunting implements occasionally took place on site C. Although the absence of bones must be taken with caution due to the poor preservation of organic material in the local environment, it may be suggested that large animals were rarely brought back to the campsite. It appears that in a spatial sense retooling was divorced from game consumption. This again is consistent with a highly mobile life strategy practiced in the back country where camping tended to be an overnight arrangement while meals were often taken at the food sources or impromptu dinner-camp localities. The mobility and transient character of camping can also be inferred from the virtual lack of grinding stones. The latter are usually associated with more systematic habitation of well established camps.

Site D

Site D is located at the edge of the gibber plain bordering the valley of Davenport Springs. It occupies a long terrace above the creek. Although the gibber plain provides a plentiful supply of quartzite, quartz and some silcrete, most of the stone material has been recovered from the steep slopes of an eroding plateau where some largish blocks of good quality quartzite can be found. Such material has been usually flaked on the spot leaving numerous isolated knapping floors in the springs area. Such floors usually contain a very large portion of massive flakes, heavy chunks of quartzite, and an occasional hammerstone. Some flakes and smaller blanks for further flaking were probably removed from these knapping floors.

Site D is characterised by low density and large artefacts. In spite of the fair amounts of quartzite cores and hammerstones little flaking took place within the campsite. It appears that only quartz was consistently flaked. The assemblage contains a large proportion of heavy elongated quartzite scrapers and retouched flakes. While these scrapers are supplemented by almost equal numbers of smaller scrapers made of chert and silcrete, quartzite constitutes the bulk of retouched flakes in the assemblage. On this basis woodcraft can be described as rough or moderately intensive. Little on-site flaking and a relatively large proportion of quartzite cores seem to suggest that cores played a different role than that of a potential package of flakes. Tentatively these cores can be seen as implements for wood chopping and rough adzing. On the whole it seems that either craft-work utilised a substantial portion of soft wood or it was more generalised than on other mound spring sites. Such a picture is compatible with the low intensity of occupation characterising site D.

It should be remembered that the area available for camping was not the most desirable (pebbly and hard surface) but it was large. These two factors contributed to a lower frequency of camping and its spread over a larger area resulting in less intensive superimposition of successive campings. Consequently the degree of recycling and reuse of raw material present on site was lower. This does not however explain the low incidence of on-site flaking.

Site E

Site E is located on the flat-top hill with a limited area available for occupation. In some respects it resembles site D with a similar proportion of different raw materials and dominance of quartzite. However, the site has a high density scatter and small artefacts suggesting intensive habitation. There was an excellent view over Davenport Springs valley from the site and convenient access to springs.

Site E shows consistent flaking of quartz and chert but not local quartzite. Quartzite cores are small (42 g) while there is a relative high proportion of moderately large flakes (mean weight 20 g). This indicates off-site flaking and suggests that cores may have played a different role, other than supplying flakes. Although quartzite cores may have been flaked in an expedient manner their almost uniform size suggest another explanation. Tentatively they can be seen as adzing tools associated with woodcraft.

Also quartzite retouched flakes and scrapers are far smaller than on the neighbouring site D. Assemblage E contains a large proportion of small chert and silcrete scrapers suggesting intensive woodwork.

Site G

Site G, located on the small dune near a quartzite quarry has an extremely dense scatter of material with small to moderately large artefacts. The site contains evidence of preparatory flaking of material brought from the nearby quarry, its regular primary flaking and further reduction due to intensive habitation. This plentiful local supply is reflected by generous use of quartzite (eg. retouched flakes, large portion of scrapers). Even a high proportion of backed blades was manufactured from the less desirable local quartzite. Other types of stone are relatively rare and they were used in an intensive manner. The scrapers are dominated by small specimens made of chert and silcrete, and there is a relatively high proportion of tulas. This demonstrates that intensive woodcraft took place within the site.

A high frequency of backed blades and animal bones suggest that retooling of hunting equipment as well as game consumption was associated with the site.

Site H

Site H is on a flat above the creek, exposed to floods. The distribution of artefacts which are grouped in small clusters about 2-3m across suggests that the site was flooded at least several times. The high density scatter and small artefacts indicate intensive habitation. Probably all four types of raw material were available locally, however they were not the best quality. Relative frequency of raw material is most balanced with dominant silcrete (30%) and least common quartzite (nearly 20%).

It is tempting to speculate that this may represent a close to ideal distribution when all material can be found nearby. However we do not know precisely the quality of material sought, nor the complete structure of demand. More importantly it seems that even a small difference in distance to raw material sources affects the structure of an assemblage. On the whole the mound spring country is characterised by a plentiful supply of stone material for flaking and in general, sources several kilometres from the site are not exploited unless for specialised purposes such as the production of blades in the Moriss Creek quarry. However, distinctive silcrete from this quarry is absent from the spring campsites. I suspect that local good quality chert would be exploited and it should find its way to major habitation sites but no such material seems to be available locally.

Poor quality chert that may have been procured in the vicinity of site H was used on the site but apparently was not transported any further in significant quantity. The assemblage is characterised by a high proportion of small chert and silcrete scrapers; smallish to small chert and silcrete retouched flakes; and a significant proportion of tulas. These tools suggest that intensive woodcraft was performed on-site. While the pattern of woodworking tools is similar to site B, here we have far more chert and silcrete retouched flakes, reinforcing the assumption about local sources of these materials.

A substantial proportion of backed blades indicate retooling of hunting equipment and animal bones show on-site consumption of large game.

Site ST

Site ST is about 10 kilometres away from any stone material for flaking and this fact is clearly manifested by the smallest flakes among the sites and small artefacts. A high density scatter indicates intensive habitation. Systematic woodcraft is suggested by the high proportion of small silcrete scrapers, retouched flakes and tulas. Backed blades are moderately frequent and grinding stones the most common among the sites. This indicates the use of local game and seeds.

Site ST is positioned near the natural boundary of habitats. To the west and north, just on the other side of the Warriner Creek, there is a local but extensive dune-field. The sand ridges are small and closely spaced. Inter-dunal flats are ideal ephemeral swamps, a suitable environment for a variety of perennial herbs and grasses. On the dunes there is a variety of shrubs, and many other plants such as herbs and tubers. Such an environment is vastly different from the gibber plains which dominate the mound spring country. Sand ridges are better vegetated and provide more variable bio-resources. One of the advantages of site ST was that it provided a good camping spot from which these resources could be utilised.

The price of exploiting these resource was to provision the site with necessary material for hardware. This involved transporting a variety of stone and ready made tools to the site. Over time an average of about 90 kg of stone was brought to every 10 square metres of the site. Considering the bio-resources it is not surprising that the assemblage shows the highest frequency of best woodwork tools - tulas, and grinding stones as well as a moderately high frequency of backed blades. This was at the expense of common tools such as scrapers and retouched flakes which are slightly less frequent here than on the other sites.

8. Conclusions

The data presented here are sufficient to propose the following base-line conclusions. The inter-assemblage variability is not random; it is stimulated by supply (reflected in the access to local stone raw material) and is stimulated by demand (reflected by the stone implements). Because supply must meet the utilitarian requirements, even the use of local material should be seen as ultimately driven by demand. Similarly stone tools were required not for making up assemblage structure, but for performing various tasks that ultimately contributed to fulfilling human needs such as procurement of food, acquisition of various materials and fabrication of implements, utensils and shelters. The use of local stone for flaking seems to suggest some stimulation by supply but it must be considered in the context of demand for sharp cutting implements. Such objects can be best or good enough, depending on the cost of acquisition. From this perspective the use of local material can be seen as another expression of economising.

Generally material transported to the sites was from not too distant sources (within 1 km of the site) - only chert and sandstone seem to be brought from far afield. On the other hand transporting stone material for about 10 kilometres to site ST appears to have been worthwhile. These examples illustrate a complexity that cannot be measured by one dimensional factors such as geographical distance or physical weight. While some symptoms of a subsistence economy can be neatly uni-dimensional (eg. frequency of raw materials and nearby supply) the underlying causes are often far more complex.

The strategy of stone material use can be partially explained by its distribution in the area and in the vicinity of particular sites. However, this strategy resulted from a demand which must have been generated by other activities within the subsistence economy. These activities involved procurement of other materials and food; manufacture of tools, implements and domestic facilities; food processing and consumption. They were all interconnected by a common goal - to provide for material necessities and ensure the well-being of a local population.

Ethnographic observations and the artefacts themselves demonstrate that implements were produced with special care for their quality and durability. Although stone tools represent only part of the technological means in processing organic materials (eg. Kamminga 1988), they seem to have been indispensable. Stone tools were required for chopping, chiselling and carving wood; cutting organic fibre, hide, and flesh; grinding and pounding hard seeds. This stone hardware was often prepared or partially prepared within the habitation site and almost always modified and discarded on the campsite. Unlike the metal tools characterised by great durability, stone tools tend to wear out far more readily (Gould 1978, 1980). Consequently stone artefacts accumulated on the habitation site provide a sound basis for learning about on-site activities through relative frequency of specific tools and different categories of debitage. Although stone materials discarded on the site tended to be reused and recycled to some degree, there is a clear assemblage structure which (with obvious limitations) reflects site use and some activities associated with its occupation.

In the next chapter I will attempt to explain what this inter-assemblage variability means in the economic and social context of the mound springs population.

CHAPTER IX
DISCUSSION AND CONCLUSIONS

> "The prehistorian is rather like the natural scientist who tries to make sense of the world of nature."
>
> Colin Renfrew 1988:158

1. Introduction

In an attempt to explain the origin and progress of human institutions (from family to state), past philosophers and anthropologists invented an individual man (not a woman) who after rational consideration was willing to engage in gender division of labour, social contract and other premeditated arrangements. However man and woman are inherently communal beings and many institutions evolved through this primary community participation rather than by the rational choice of individuals. This situation is paralleled in prehistory where the most valuable, mass evidence of the past came through the community participation and perpetual replication of adopted ways of life. Such replication assures the stability and identity of a community but it also provides necessary material for change initiated through internal drift or accelerated by external forces. Both replication and change operate within the broad framework of Darwinian-like selection, where human deliberation and individual decision play but a minor part.

In contrast to the abstract individual, community life is about organisation on many different levels. Some social institutions such as marital rules or kin system produce no direct archaeological evidence but subsistence oriented strategies and supporting technologies are well reflected in material records. If archaeologists aim to cast light on something akin to culture or ethnic entity in ethnology, the organisation of life strategy is the most accessible and often only practical representation of the past culture. It must, no doubt, appear dry and bare to the students of social anthropology accustomed to the wealth of cultural manifestations including beliefs, art and oral literature. Prehistorical records reflect primarily (and often exclusively) cooking, eating, and a handful of craft-works. However such limited materials document human interaction with the environment and the organisation of community life on the strategic level. This is worthy of exploration since the organisational dimension contributes most to our understanding of 'human natural history'.

In the former chapters I argue that inter-site variation is largely caused by differential location of stone sources and subtle variation in vegetation in the mound spring country; intra-site uniformity is a product of overlapping camping episodes, each of a very similar nature in the basic modes of subsistence and economic tactics (taphonomic processes such as gravity, wind, amd water distort this uniformity, advancing from site peryphery towards the core area).

I demonstrated that the variability of assemblages can be meaningfully explained by different modes of stone procurement, treatment, use, maintenance, and discard. This can consistently be linked to the organisation of activities involving lithic raw materials and their products. Although these activities are represented only by several categories (eg. flaking stone material, woodworking, seed grinding) they occurred in different modes, frequency, intensity, and association with different stone materials. These different modes or technological solutions must have been integrated into a broader framework of organisation represented by the life strategy (compare chapter III).

In this chapter I will attempt to infer the life strategy practiced by the mound spring inhabitants. In the following sections I will outline the rationale for such inference and the potential of stone artefacts in this approach. I will draw inferences from four kinds of evidence: a) technologies in the context of environmental variability as represented by geographical modules - sites; b) location of stone material sources in relation to the mound spring campsites; c) location and assemblage differences between the mound spring and non-spring sites in the area, and; d) assemblage variability among the mound springs themselves. In doing so I will refer frequently to the results presented in the preceeding chapter (VIII).

2. Rationale

From the archaeological perspective a life in the past can be seen mainly as an interaction between a human population and the environment. The environment imposes specific constraints and offers certain resources; a population adapts to the given conditions by implementing appropriate technologies and life strategies. Most environments are hostile to human beings and could not be occupied without the aid of technology, the central component of archaeological records. So, human existence relies on organisation and technology that must be adjusted to the environmental and social requirements. Different human populations do similar things in somewhat different ways. The difference is influenced by environmental conditions but is mainly shaped by specific solutions to daily problems (best reflected by the organisation of technologies) and the life strategy (best expressed by the mode of land use).

In the materialistic view of reality the subsistence-related activities constitute a driving force for the variability observed in material culture within and between different populations. The variability is generated by selection, a process akin to and indeed substantially equal to, selection in the Darwinian concept of evolution.

The material for such selection is drawn from existing and potentially accessible solutions to human needs. Selection itself proceeds with respect of environmental constraints that impose limits on one hand and incentives on the other. Solutions, technological and strategic, are worked out in dynamic interaction between human population end environment. However, environment in this interaction is not a boundless universe of opportunities but is mediated by the rules of economy, crudely perceived as constraints of weight, distance, time, and energy.

Within the bounds of the material world and the rules guiding energy flow, technological and strategic solutions must, above all, fulfil at least one crucial requirement, that is to be workable and practical in order to support human populations in their drive to perpetuate themselves through time. This requirement of accordance between technologies and the rules of real material world, provide a convenient point of departure for archaeologists who try to make sense of material records of the past (eg. Gellner 1982; Binford 1987b, Torrence 1983, 1989a, 1989b).

In an archaeological perspective a culture should not be understood as an ornament but a hard material core of existence. Technological solutions are rational and practical in the sense that they provide a workable support system for humans who are poorly biologically adapted to most environments. Thermal regulation alone would prevent people from inhabiting Canada, Europe and most of Australia. When this is taken into consideration it becomes irrelevant to ponder whether stone artefacts may possess some hidden or explicit stylistic meaning carefully nurtured by their producers in order to maintain and reaffirm ethnic or tribal identity (eg. Close 1978; Sackett 1982, 1986; compare Binford 1973; Parkington 1986; Clark 1989:29-33). Stone artefacts especially are positioned at the base of material implementation. Most stone tools appear to be the only and/or the best available hardware to extract, process, and shape the large range of organic resources. Cutting fibre, skin and meat; chopping, chiselling, and carving wood; smashing bone, cracking nutshell, and grinding seeds are just some of the examples. As a result of its indispensable role and requirement of energy expenditure, the stone itself became a subject of economic and rational consideration. Stone quality, sources, transport, processing and storage need to be organised in an economical manner.

3. Stone artefacts as a basic evidence of life strategy

Although stone artefacts represent only some aspects of subsistence and related technologies, they provide a strong reflection of organisation, anticipation and planning. In this system most stone tools are positioned between procurement of organic resources, their processing, production of other implements, acquisition of food and consumption. As hardware they play an important role in mediating between environment and material implementation of the subsistence system.

There are several aspects of stone artefacts that make them a valuable archaeological record in casting light on the past life strategy.

a) The stone artefacts are more durable than most other materials and are usually the best preserved component of material evidence.

b) Because of the relatively short time-span before a tool wears out (in comparison to metal tools), stone tools were often replaced, discarded, and consequently accumulated on some locations in large numbers.

c) Stone tools are largely used for processing other materials and therefore they reflect some aspects of subsistence-related activities on one hand and economy of stone materials and implements on the other.

d) By representing basic hardware stone artefacts are subject to the rules of economy where the energy input and gains must be taken into consideration (in contrast to the signs and symbols which are inexpensive in this sense and guided by different rules, far more elusive in an archaeological context).

e) Stone itself is relatively heavy and because of this it provides extra incentive for strict application of rules of economy in areas where expenses and benefits must be carefully balanced.

f) The stone artefacts are shaped, rejuvenated, repaired and recycled virtually by processes of reduction, and consequently their history is reflected in the tools themselves (eg. intensive reduction of scrapers) and accompanying debitage.

g) Stone artefacts are distributed in two modes in the landscape: a) as clusters (eg. sites) and, b) dispersed. The dispersed distribution is difficult to study (eg. Thomas 1975; Jones et al. 1989) and traditionally archaeologists focused their attention on the cluster distribution which provides the most solid evidence for land use. The clusters (eg. sites) are the geographical modules defined by several sets of coordinates such as access to and quality of water, local bioresources, inorganic materials for stone tools and other implements, or presence of natural shelter. Human behaviour within such geographical modules should be sensitive to the immediate local circumstances. Consequently artefacts making up the site content should reflect the behavioural pattern of a population sample (a group of people) and specific geographical space (eg. area around the habitation site). The number of sites (within a single chronological plane) would map behavioural variation through space and within the population. Such mapping should reveal some aspects of land use and life strategy.

h) Consequently distribution (absence/presence and relative frequency) of different kinds of stone artefacts between the sites reflects variability through the space and therefore aspects of life strategy practiced by the local population.

In the former chapter I argued that the morphology and size of tools reflect the intended function and actual use. I also demonstrated that the final form is influenced by access to and cost of raw material as well as intensity of use. In order to address this relationship between stone tools (technology) and strategic organisation of life I will evaluate my findings against the more systematic framework which accounts for the logic of economising and its constraints on the organisation of human behaviour. Binford's concept of curated technology provides a relevant frame of reference.

Binford (1977; 1979) introduced a distinction between curated and expedient technologies. In this concept some tools tend to be used repeatedly and are regularly repaired, resharpened, and/or rejuvenated (eg. stone axes, tulas, grinding stones); other tools are (often) used for a single task and readily discarded (eg. unmodified flakes used for cutting, retouched flakes). A similar distinction described as 'ideal' tools and 'casual' tools was directly observed in the Lake Eyre district (Horne and Aiston 1924:87).

Both curated and expedient technologies are different measures to minimise the cost of material use. The concept is especially useful in explaining variation within stone tools and implements. The rationale can be expressed in the following way.

Because stone is heavy the artefacts should ideally be used near sources of lithic material; if there is a real need to use them far away from the source they must be light weight and portable or positioned in the strategic locations (eg. base camp).

There are several categories of wood-working tools that can be placed within the framework of curated/expedient technology.

In an ethnographic context tulas represent specialised, curated tools, used and maintained for a prolonged time. Accordingly the material for tulas is of the best quality, and tool acquisition is complex and expensive. Production of tula flakes involves a high risk of failure and is therefore wasteful as far as volume of raw material is concerned. Tula flakes are produced at often distant outcrops of lithic material, probably by a special task group, and transported to the base camp in large numbers at a time.[1] Back in the camp, some tulas are hafted in a wooden shaft, 'koondi', as specialised adzing tools used for substantial woodcraft in the habitation site. Some (most ?, compare Cane 1992) tulas are hafted on the handles of spear throwers, themselves versatile and portable implements. It seems that 'koondi' tulas were used largely, if not exclusively, in the camp; tulas in spear throwers were a part of the portable equipment related to the men's collecting/hunting trips. While tulas were used in and out of a campsite context, they have been largely discarded within habitation site where most replacement (retooling) took place.

The curated character of the tula, in the archaeological

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[1]. I assume that such strategy was largely used in the mound spring country. Because no regular cyclical movement of people to the quarries was possible due to unpredictable succession and length of droughts, embedded procurement of tulas (sensu Binford) is less likely. The frequent presence of tulas within the habitation sites suggest that re-hafting took place in the campsites. If this was the case, one would expect that the tools were procured and transported in large numbers at the time, as documented by caches of tulas (eg. Hiscock 1988). However I do not consider that such a mode of procurement is sufficiently documented for the mound springs nor that it is common in the whole arid Australia. Witter (1992b) provides an example of aquite different strategy from the White Cliffs and Tibooburra area and I believe that different strategies were in place in other regions of the arid country.

context, is documented by its consistent reduction by resharpening; it is rarely discarded before being reduced to 1/4 of the original length. Reduction can be read as the implicit manifestation of hafting.[2] Since the tula is the most curated stone tool its discard rate is significantly lower than other tools of comparable function; there is only one tula discarded per 6.4 scrapers.

Scrapers, as discussed in the former chapter, represent more variable tools. When grouped by association with different raw materials, size, and degree of reduction they display a range of tools where different levels of curation can be inferred. Large quartzite scrapers seem to be the most expedient with small chert and silcrete scrapers the most curated. The later were intensely reduced (eg. length/width ratio) indicating prolonged and/or repetitive use. They were most likely hafted since their thumbnail size would present difficulty in holding the tool and applying necessary pressure in action. The group as a whole is strongly associated with the long-term habitation sites where they were produced (often developed through the retouched flake stage), used, and discarded. Their discard rate is visibly lower than tools with comparable function; one scraper is discarded per 2.2 retouched flakes.

In this category of wood working tools the retouched flakes were the most expedient tools, discarded 14.6 times more often than tula. It must be remembered that retouched flakes were tools developed through use, although not to such a degree as scrapers. Therefore they document some consistency in wood processing activities, above casual cutting or scratching that can be performed by unretouched flakes. In terms of relative frequency retouched flakes represent a much stronger component in transient campsite assemblages than in the spring habitation sites (58.4% of tools on site C against 42.7% - the mean for seven mound spring sites), attesting to the validity of the relationship

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[2]. Hafting as a time and material consuming solution appears necessary only for long lasting or otherwise curated tools and a vital component of the implements designed for procurement of food where the high risk of loss is involved (eg. spear barbs).

between the overall site function and component of curated technologies.

If the ratio of discard provides any guide to the durability of tools, one can assume that after initial investment tulas presented significant savings of time and material. Its real value however, seems to be strength, sharpness and above all portability, all in all, a price evidently worth paying. Such a tool would be far more important in the locations away from the supply of lithic raw material than close to the stone outcrop. Accordingly, while tula represents 2.4% of the tools on the mound spring campsites (mean for 7 assemblages) it represent 10% on site ST, the site farthest from any sources of lithic material (Table 26, p.230).

The seed grinding slabs fall into the category of curated implements but this technology goes beyond the concept of curation. Although grinding slabs were transported to the strategic points in the landscape they were not portable implements. Unused grinding slabs would weigh nearly 30 kg (McBryde 1992). Seed grinding implements can be placed within the concept of risk avoidance as developed by Torrence (1989a). She sees the risk avoidance or prevention of loss as the crucial factor determining technological solutions in the field of food procurement. With severe consequences of failure (eg. starvation) the relevant technology will be better developed, more formalised and accordingly people will be prepared to invest more time and energy. With the milder consequences of loss, technological devices may be less perfected and less expensive.

Grinding stones represent technology that is well-developed, reliable and formalised in response to severe consequences of failure. At the same time it is costly, probably the most expensive among stone technologies in arid Australia. Such a reliable but costly solution attests to the importance of seed use and also to its role in the overall life strategy.

The grinding stones, as known from the ethnographic records, are intended for prolonged, heavy duty work in grinding hard seeds (Smith 1985, 1988; Cane 1984, 1989). The large size of the stone slab itself assured its functional efficiency and durability. Apart from reduction caused by grinding itself, stone slabs were occasionally redressed to roughen their surface. They were also subject to breakage, especially at the latter stages of their service when the slab became too thin for its size to sustain the pressure. This study suggests that broken pieces of grinding stones were further utilised; some flat handstones are made from the broken grinding slabs, and smaller pieces were further reduced beyond the level of visibility. For an explanation of this process I can only offer a speculative suggestion that small pieces of sandstone were used as tools functionally similar to a file or sand-paper. The complete utilisation of grinding stones and remaining pieces indicates the value of both, and reaffirms the lack of appropriate sandstone sources in the sites' vicinity.[3]

The sandstone slabs were shaped at the outcrop and transported back to the 'strategic points', that is, to the mound spring campsites. With grinding stones in the campsite the local group was gaining access to vital processing equipment, necessary for the use of a laborious but relatively reliable food resource, seeds, staple throughout arid Australia before contact. The grinding stones support the proposition that the mound springs were locations for the base camps, since stone slabs have been brought not to the sources of seeds but to the sources of water, strategic positions for camping. This association also suggests that mound springs were occupied more often, for prolonged time, and above all during dry hungry periods. Distribution of grinding stones through the area can be seen as the physical manifestation of strategic space planning and organisation of land use.

Both grinding stones and heat retainers (cooking stones) are consistently present on the mound spring campsites while they are virtually absent in the transient campsites away from permanent water. In general they are associated with the long term camping that is the characteristic of mound spring campsites, and with

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[3]. A few complete and some freshly broken, but all visibly used, grinding slabs observed on the spring sites can be explained as the stock in current use which remained in place after occupation of the springs was abruptly terminated.

a wide range of domestic activities. Although heat retainers can serve as a fuel conservation measure by allowing a fireplace to generate or maintain heat longer without extra consumption of firewood, they were also used for cooking. Considering the importance of seed and its laborious preparation and cooking, it is possible that grinding stones and heat retainers are linked by a more systematic functional relationship. It is possible that the use of seeds required both grinding stones for preparation and cooking stones for baking (Witter 1992b).

The backed blades are inexpensive to make and easy to carry. They may be, tentatively, associated with fighting and hunting equipment. In the curated/expedient equation backed blades must be seen as readily disposable items but they also fit neatly into the risk avoidance strategy (Torrence 1989a). Their importance must be in loss prevention when a spear armed with barbs was likely to cause a fatal blow and/or prevent game from escaping. However in contrast to reliable, formalised and expensive grinding stone technology, barb-armoured spears represent integrated products in which sharp blades constituted a vital component conveyed by versatile, portable and inexpensive technology. The best backed blades are made of thin flakes which can be obtained from small quartz pebbles, widely distributed in the mound spring country, or any other fine grained lithic material. The backed blades can be made from any flakes of adequate size and for that matter recycled material such as discard-debitage may provide sufficient supply. On the other hand small cores (about 100 g) can provide portable sources of freshly made and therefore sharp flakes for the backed blades.

Unlike scrapers, grinding stones, and many tulas, backed blades were to perform their essential function in the off-site context. Their presence in the site reflects primarily production and retooling. Therefore it is consistent that a high frequency of backed blades is associated with assemblages containing animal (macropod) bones but only in the spring sites. Such a pattern of distribution suggest that a) assemblages with the high frequency of backed blades reflect maintenance of hunting equipment (sites B, C, G, H, ST); b) game was regularly transported back to the spring sites with a high component of backed blades (eg. B, G, H, ST), and; c) game was rarely transported to the transient sites away from the springs (eg. site C).

4. Sources of raw material in relation to the spring campsites

Sources of stone are fixed in the landscape and often localised as specific outcrops. Although stone is an important resource, outcrops alone do not attract human habitation. This common spatial disassociation of stone sources and habitation sites provides important evidence for inference regarding organisation of life strategy:

a) Habitation sites are positioned near the water, preferably on sandy ground, and close to the supply of wood. It is obvious that water was vital, and constant, immediate access to it was given the highest priority. Although technological means existed, long-distance transport of water was not regarded as a viable solution, due to the high cost of such an undertaking. Instead, during favourable conditions, stone material was transported to the habitation sites.

b) In contrast to water (and most of the food) 'consumption' of stone can be comfortably delayed. Transport of stone from its source to the habitation site can wait for the appropriate occasion (eg. when rainfall permits departure from the springs) and because of this some surplus of material is needed. When supplies run low and/or re-supplying is expensive, more intensive use of artefacts and recycling of stone material occurs (eg. site ST).

c) Stone is brought to the site for specific use as well as contingency planning: 'with a core in camp, the flakes could be struck off as necessary' (eg. Binford and O'Connell 1984 [quoted from Binford 1989:135]). Such an attitude is good evidence of planning including contingency measures.

d) Planning, in this context, encompasses space, time and energy input. Stone is rarely, if ever, brought from its source in the form of randomly collected pieces. Instead it often undergoes, at least, preparatory flaking at the outcrop to produce smaller, portable packages of material (eg. cores); often some primary flaking or even manufacture of half-products (eg. blades for knife or tula flakes).

e) In my sample only material from the nearby quarry was brought to the campsite (quartzite on site G) before preparatory flaking; presumably to move the operations closer to water and shade. Stone collected within a similar distance but from widely dispersed sources was usually subjected to on-the-spot preparatory flaking, and only developed cores and ready flakes were brought back to the site (eg. sites D, E and H). However small quartz pebbles, the best local material for sharp cutting flakes, were always brought intact to the site (contingency measure) with the minimal expenditure of energy.

f) Rare and distant material of superior quality (eg. chert) was brought for specific use, mainly in the form of ready flakes (eg. tula) or small cores and subsequently intensely reduced by flaking, re-sharpening and/or recycling.

g) The points 'd', 'e' and 'f' indicate that stone processing was divided into stages separated in time and space. This can be seen as a spectrum of economic solutions where conservation of energy is a prominent feature. At one end of this spectrum small pebbles of quartz were brought to the site for subsequent production of flakes; presumably fulfilling the role of handy, immediate, and emergency material for hardware. At the other end are tula flakes, seemingly produced at the quarry and transported to the distant habitation sites for use as a vital component of standardised tools. In between there is a whole range of solutions where procurement and processing of material is usually divided into stages at different times and places.

5. The spring and non-spring campsites

The contrast between the transient campsites away from the permanent water and the mound spring campsites provides another dimension to this framework of organisation. I have argued (chapter III) that the first were an overnight arrangement while the second were campsites inhabited for at least several days or weeks (occasionally months ?) at a time. The tool to flake ratio is significantly lower on the transient sites than on the mound spring campsites (Table 3, p.84), indicating a marginal role for craft-work which was undertaken impromptu according to immediate needs. It also suggests that stone, organic materials, and even food was not regularly transported to the transient camps. The reverse is true of the established campsites located near the springs. Here materials for crafts and for food processing and consumption were regularly supplied through the general and/or specialised collecting trips. The mound spring campsites represent evidence of the most localised and intense domestic activities. It is therefore inferred that while camping at the springs, local inhabitants behaved as collectors (in Binford sense) bringing resources back home; then after rainfall, they ventured away from the springs acting as foragers, readily and rapidly moving camps to the resources.

It may appear trivial that longer and better established camps have been consistently located near permanent water while transient short duration and incidental camps were common in the back country. Such a pattern seems to conform to the most logical response induced by the environmental constraints. However, it provides more subtle evidence of life strategy. While the back country offered no opportunity for establishing longer lasting camps, spring locations did not restrict movements. It is likely that even during harsh drought, and perhaps more so then, the collecting trips could easily be made to the neighbouring springs and therefore could easily be converted into residential mobility. And yet it appears that habitation at the springs was more stationary, beyond the immediate dictum of environmental requirements. It seems that in spite of the benefit of and desire for mobility, periods of stationary habitation at the springs were favoured. Although such temporary sedentism did not remove the necessity for the collecting trips at least for some of the community members, it must offer another benefit.

Because this stationary phase of life largely overlaps with dry hungry periods, I am inclined to think that it was an economic, if not survival, strategy rather than indulgence.

Ethnographic records suggest that camping life offers young children and elderly people a better chance to rest and some duties can be easily rotated between households and camp members (eg. Lee 1979; Cane 1984). My data do not allow me to explore such a possibility directly but it is likely that the camp was an arrangement where technological means supporting a social system can be best integrated and maximised in order to provide the most effective and least expensive 'artificial environment' (compare Binford's 'cultural geography', 1987b).

It can be argued that the base camp provides such an effective supportive system in some vital aspects of preservation and replication of human population.

In the area of protection and comfort the base camp provides shelter from the sun, wind and cold in the form of huts, wind breaks, fire places and other camping facilities. Since Aboriginal people in this area did not use clothing it is likely that some form of camping served as a refuge in which excessive adverse conditions such as bitter cold, strong wind or summer heat could be endured with minimal trauma. This can be corroborated by Reuther (1981) who provides the wealth of oral and linguistic material suggesting that, especially when travelling, people were very conscious about overnight camping. They considered quality of water, supply of firewood, and sleeping arrangements such as windbreak, sleeping with other person or dogs, and within the warmth of a campfire.

The base camp also permits the maximisation of food resources. It appears that through division of labour and the rotation of duties within and between households, some camp members were permitted to utilise food resources which required more time for collection and processing; food that was more expensive. The collection and preparation of seeds must be one such food which can be utilised best, if not only, in the base camp. Grinding facilities were too heavy to move around and in practical terms were permanently assigned to base camp localities. Time too played an important part in maximising the food resources. Protein and fat from the animal bones are likely to be better utilised in the camping base than during short stops in the mobile mode of life and this is reflected by the archaeological records. Highly fragmented animal bones are usually associated with the mound spring sites (base camps) while they are virtually absent from the transient campsites away from the permanent water.[4]

The locations of the mound spring campsites themselves ensured constant and easy access to water, not a minor point in the summer drought. It appears that transporting water was far too expensive and base camps could not be located away from the water sources. Since the mound springs are often related to the creeks, the most likely location for trees and shrubs in the area, spring camps are often near supplies of wood. Finally, while the base camp was itself a longer or shorter temporary establishment, the campsite was permanent. It means that things left on the site after people moved out were not really all discarded. The grinding stones, anvils, and some hammerstones were brought on the site for prolonged service and they remained there as the implements for subsequent use. Furthermore stone material that was brought and discarded on the site during many former episodes of camping can always be re-used in some activities and/or in an emergency. Gradual accumulation of stone material on a site over time provides a pool of 'second hand' supply which can be, and indeed was, utilised. This process is best demonstrated by intensive reduction of stone artefacts on campsites that were the most consistently and often occupied (eg. sites B, E, H, ST, Fig. 34, p.201).

6. Variability among the mound spring campsites

The seemingly undifferentiated landscape (at least within the bounds of the stony desert) was not used in a random manner as would be expected, and often is reinforced by broad generalisations. For example I have demonstrated that in the

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[4]. It can be assumed that intact bones were more attractive to the scavengers and easier removed from the site than small highly utilised pieces. I wish to point out too that highly fragmented animal bones may signify stress during the famine period (Gould 1980:194).

spring country where the potentially useful stone, quartzite covers almost every square kilometre, other stone sources are not uniformly spread over the landscape. It is evident that the bulk of silcrete was procured from the outcrops which are numerous but not evenly distributed and rarely found in the spring vicinity. Although I attempted to characterise plant resources in the surroundings of the mound springs (chapter V), there is a practical limit to projecting a current plant distribution pattern into the pre-contact period. Nevertheless it must be assumed that there was always a patchwork of plants, mainly in the form of small pockets, which displayed subtle variation through the landscape.

I suggest that it must has been this variation of resources in the landscape (vegetation and stone) that prompted the development of a land use strategy where different focal occupation spots were assigned slightly different roles in the spatial organisation of subsistence and related activities. Nutritional requirements can be satisfied by various combinations of food. Similarly there is often more than one kind of material suitable for a particular product (eg. tulas are made in nearly equal proportions from chert and silcrete).

If economy played an important part in the local life strategy (which is well demonstrated for the stone artefacts) it is natural that different camping localities providing different benefits and disadvantages must have been considered and assessed from this point of view. In the complex play of spatial configuration of resources and the human tendency to economise on the subsistence related work, specific localities can be associated with a given configuration of local resources and, accordingly, this would lead to the specific combination of activities. Organisation of subsistence related behaviour in this fine grained perspective appears to be locality specific.

However, if the different localities provided specific incentives it was still up to the people to select a location-specific strategy, since there must have been more than one strategy possible. The campsites located at the same spring (eg. A-B and D-E) provide adequate example. I demonstrated that the mound spring campsites reflect access to different resources (eg. quartz at sites A and B), but variability between campsites located at the same spring testify to some freedom of choice where different strategies are still allocated to different sites. This variability reflects organisation of settlement and related activities within a spring area and possibly some social determinants of such organisation. The first manifests itself in acute sensitivity of a camp strategy to its specific location and its immediate surrounding; the second can only be inferred from the fact that such individual strategies were maintained at each site for some hundred years.

People selected a particular strategy and remained faithful to this selection on the population level (in the synchronic plane) and through generations (in the diachronic perspective). If this path had been transgressed more than in an incidental manner, one should expect the significantly higher intra-site variability and a much lower inter-site variation.

7. Cultural geography of the springs

People modify their natural surroundings, a fact difficult to overlook in the 20th century. Hunter-gatherers too organise their life not only by adapting themselves to what the land has to offer but also by adapting the land to their needs. This is done by establishing facilities of long lasting or ephemeral character (eg. grinding stones and windbreaks respectively). The more permanent the facilities the more likely long term planning and anticipation is involved (Kent and Verich 1989). These arrangements in the landscape reflect organisation of land use and life strategy itself. The mound spring campsites document such permanent arrangements where some facilities to aid human needs are established and maintained. Although the camps are only a temporary arrangement, the spring campsites are evidently permanent.

The mound spring campsites are spectacular examples of camping activities in the area. It is difficult to speculate if camping facilities were necessary for the successful occupation of the mound spring country but they no doubt greatly enhanced human ability to cope with this difficult environment (Binford 1987b). In this context the mound spring campsites appear not as abstract geographical locations but as places defined by the set of natural and strategic coordinates.

Primarily the mound spring campsites must have been perceived as secure camping locations, providing reliable access to the vital resource - water. However, this is a somewhat abstract concept which can be expected from the explorers making their way through the 'new land' or geographers analysing maps of distant places. The local inhabitants live and make their planning within a concrete land and existing settlement system. For the mound springs were not only convenient locations for living but established camping grounds.

The spring camping grounds were established in the physical and conceptual sense. Repetitive deposition of discard on the same site over centuries document that not a spring in general but specific sites were defined as camping grounds. Remaining fireplaces testify to the existence of facilities that have been constructed on the site during the episodes of its occupation. Complete grinding slabs, handstones, hammerstones, and anvils document that some equipment has been customarily left on the site with the intention of future use. The same must be true of the supply of lithic material; within the stone artefact scatter one can always find a number of cores suitable for further flaking, some barely developed and ready for exploitation.

Providing a limited number of permanent water sources and therefore a limited number of potential, convenient camping grounds, it must be assumed that every member of the local community camped many times on different sites in the area. This practical experience of individuals formed a communal memory and cultural, not merely geographical, knowledge. Communal memory is an institution itself, a pool of knowledge and shared experience to which people turn for reference to social identity and cultural guidance. I would argue that variability between the mound spring sites can be explained as the reflection of this shared, communal memory and cultural experience. Even if the prehistoric view of the past population is simplified, and substituted for by the subsistence system, its very structure and organisational quality demands an explanation in which communal memory and identity is recognised. The archaeological record itself is a product of the communal endurance, shared experience, and participation.

In archaeology culture is often understood as a relatively rigid stencil which must be impressed on stone tools, assemblages, and settlement system (eg. Clarke 1968). But clearly the complexity of social make up and variability of the external world dictate that even simple communal actions such as food gathering, hunting and procurement of various materials is scheduled within the occupied land and in the time divided into durinal, seasonal and other cyclical changes. Human activity is sensitive to the immediate surroundings and narrow time-slots. Therefore technological and organisational responses to daily needs are time and place specific rather than a homogenised signature of a distinctive cultural patterns (eg. Binford 1984; Binford and Sablof 1982). So, it is important that archaeological records are seen as both uniform on one level and variable on the other.

Such generalised culture-specific stencils appear to be the product of model-building processes in archaeology (Wobst 1990) where variation is filtered out as a 'noise'. However, when the variation is removed from the data matrix the potential for fruitful research becomes severely limited. It is common that the regional cluster of sites, representing the same chronological plane, is forced into a single box. Be such a box called technocomplex, regional type, or culture it provides little scope for research into the life strategy or historical process in prehistory. What emerges is that there are local groups across space and time and that such groups reflect fragmentation of the human population into entities similar to the cultural provinces, ethnic groups, or tribes.

Permanent establishments such as the mound spring campsites, occupied intermittently during some hundred of years, document the existence of the life strategy and its arrangement in space.

Variability of the spring assemblages reveals the complexity of the local subsistence system and, by inference, cultural and social complexity of the mound spring inhabitants. Effectively this provides the material for a study of historical process in the past.

8. Variability and archaeological records

Many research projects provide sufficient pretext to enter into ongoing debate about archaeological practice and theory (eg. Binford 1989a). My study warrants comments in several areas of archaeology such as investigation of surface sites, site patterning by natural and behavioural factors, and size-grading in the analysis of stone assemblages. I think however that more important implications of this research are in another area, namely the variability of archaeological records.

In the following paragraphs I will discuss briefly what I consider to be the important implication of this study. Although this implication is simple, it challenges the way in which archaeologists see reality and accept the way to learn about the past.

We often forget that 'reality does not speak to us objectively, and no scientist can be free from constraints of psyche and society. The greatest impediment to scientific innovation is usually a conceptual lock, not a factual lack '(Gould 1991:276). The archaeology of hunter-gatherers (and not only it) operates within several basic views of reality such as historical, functional, and some derivatives such as structuralism, (Rindos 1989). Although these views seem innocent, conveying a large measure of logic, and are often accepted without consideration of their implications, they exercise a powerful control over the research conduct and the resulting ideas of the past.

For the first six decades of this century archaeology was largely preoccupied with establishing broad cultural stages in time and identifying distinctive cultural traditions. The first were often equated with human ascent and cultural progress, a theme repeated dutifully in many publications. The second was often understood to represent cultural, social, and ethnic entities, subject to diffusion, invasion, and migration in a historical fashion.

These concepts were bred, not surprisingly, within the typological view of reality where the world is 'composed of a series of discrete entities, variation <u>between</u> which is of explanatory significance but variation <u>within</u> which is noise' (O'Brien and Holland 1990:37, original emphasis). This view of reality was reinforcing the archaeological picture of the past, while the characteristics of the past were in turn empowering the typological concept.

The alternative view of reality is the materialist one. This postulates that phenomena are in a state of constant change and therefore can be identified as 'kinds' only in the specific time, space and historical context, as they are not universal archetypes. The change is not a transformation from one kind to another but rather a shift in the attribute frequency and cause is the ultimate ingredient of historical process. Explanations are closely related to observed variation and inferences are made about the nature of change by identifying and measuring variation (O'Brien and Holland 1990:37-38).

In the typological concept, variability must fit the model and can often be forced to conform by manipulation of typology and its statistical expressions. In less dogmatic versions, the pattern of variability that does not conform to the model appears as a problem which requires explanation. In the materialist concept 'variability is not the problem to explain. Instead it becomes the way of approaching explanation' (Rindos 1989:22).

The contrast between these views of reality surfaced recently in a discussion centred around Palaeolithic research in Europe but concerned essentially with how to understand and explain historical process in prehistory. Otte and Keeley (1990) representing virtually the typological view assumed that: a) retouched-tool types are archetypes related to the identity-conscious people; b) assemblages can be grouped into regional entities with discrete boundaries in time and space; c) regional archaeological entities must represent social groups such as people, culture, or tribe. With this preconception historical processes can only be explained by diffusion and migration (eg. Otte 1990), even when closely scrutinised evidence resists such explanation (eg. Clark 1989).

Clark and Lindly (1991), on the other hand, maintain that: a) basic retouched-tool types are practically universal (meaning Europe and Levant); b) no Upper Palaeolithic assemblage is fine-grained enough in resolution and integrity to permit identification of identity-conscious social units; c) under careful scrutiny the Upper Palaeolithic assemblages do not group neatly in time and space but display complex spatio-temporal variation, and; d) the fluidity of hunter-gatherer's group territorial boundaries would have confounded patterns of ethnicity. This is a remainder of a similar debate, which erupted two decades ago in response to Binford's functional interpretation of the Mousterian assemblage variability (Binford and Binford 1966; Binford 1973; Collins 1969, 1970; Mellars 1970; Bordes and Soneville-Bordes 1970) with the difference being that the materialist camp now marshal much stronger and better developed arguments (eg. Parkington 1986; Binford 1987b; Clark 1989).

Australian prehistory inherited a heavy burden of typological tradition (eg. McCarthy 1977; compare Mulvaney 1971, 1977, 1981; McBryde 1986) where little variation was perceived and minimal change admitted to happen in a past. Although regional studies (eg. McBryde 1977; Attenbrow 1987; Pardoe 1988; Smith 1988) redress this bias, there are still some strong typological concepts which tend to iron out variation. The 'core-tool and scraper tradition' is the prominent example. In the same time frame which is covered by this tradition in Australia, European prehistory was punctuated with many abrupt cultural transformations. The fact that these changes are still commonly explained by diffusion and migration (eg. Soffer and Gamble 1990) is 'a conceptual lock' of Europe's own typological tradition.

Some examples of the current regional archaeological research suggest that the question of data resolution and the search for different formula of explanation are being embarked upon.

Intensive research in the central Hunter Valley resulted in recognition of small areas with distinctive differences in stone artefact assemblages. This variability has been demonstrated and explained through <u>technological modes of tools manufacture</u> (eg. Hiscock 1986; Koettig 1992). Confined to the narrow geographical space and chronology (largely middle to late Holocene) the evidence provides an opportunity for research with increased resolution and high density in data matrix.

The Pleistocene cave sites in South-western Tasmania present a different opportunity. Here variability among assemblages prompted the search for explanation in the whole <u>subsistence model for very small local group of inhabitants</u> (Allen <u>et al</u>. 1988; Jones 1990).

Another good example is the regional study of western Victoria. The concept of intensification was developed here as a possible explanation of cultural change in archaeological records (Lourandos 1983, 1985). This theory has gained some prominence but also aroused significant controversy. Bird and Frankel (1991a, 1991b; Frankel 1991) challenged this theory on the basis of <u>radiocarbon dates and scale of resolution</u>.

The wetland sites at South Alligator River in the Northern Territory provides an example in many respects similar to the mound spring sites. Well established chronological framework is confined to the last 1000 years, and the sites with 'millions of stone flakes and other artefacts [...] present on their surfaces' (Jones 1985a:291) are linked within a common settlement system.

This region has its own history of archaeological explanation which attempted to encompass both ethno-historical and archaeological records. During the past two decades several attempts were made to explain variation between upland and flood-plain sites (White and Peterson 1969; White 1971; Schrire 1984). The comprehensive review of these explanations was recently provided by Allen and Barton (1989). It appears that a promising explanation combining a cultural historical approach to archaeology with a cultural ecological approach to ethnography failed due to the crude resolution of archaeological data (Allen and Barton 1989:19). Further research demonstrates discord between cultural and environmental changes, providing some support for an explanation in which social causes of variability may be more prominent. Recent studies acknowledge the need for analysis of 'assemblage variability, both regionally and according to seasonally induced functions' (Jones 1985a:295) but they seem reluctant to embrace any explanatory model or to furnish a definite theoretical framework. However it seems that emphasis is given to the subjects most congruous with social determinants of variability and change (eg. projectile points, their origin, diffusion and socially variable context of use) (eg. Allen and Barton 1989).

In his study of archaeological assemblages in Western New South Wales, Witter (1992a) demonstrated the strong correlation between stone use, treatment, and technology on one hand and availability and form of lithic raw materials on the other. <u>The variability is largely determined by raw materials and application of appropriate technology</u>, thus encompassing environmental and technological determinants of diversity. By addressing variability rather than 'cultural' differences between regions, Witter moves towards theory crafted in accord with evolution and selection (Witter 1992b:34). He points out that archaeology needs theory which would explain cultural change through its internal process in response to environment and socio-political context.

Such theory is already being employed in other areas of prehistory. For example Pardoe (1988, 1990, 1991) arrives at some social determinants of diversity and change through research being substantially an approach of natural history. He maintains that 'in prehistory at least, culture is biology and biology is culture' (Pardoe 1991:69). So the focus on population and variability in archaeological studies seems to be far more fruitful than the more traditional approach revolving around a cultural history.

My own study provides another example of the shift from cultural history to research more akin to natural history, where emphasis is placed on population and variability. The concept of life strategy appears to perform well in integrating environmental variables into social strategies and isolating causal links in the conjunction between environmental constraints, social demands, and technological means.

There is no doubt that prehistory deals with human populations of the past, but simplistic correlations between the variants of tool types and social or ethnic entities cannot be assumed. The archaeological records are too crude and too complex to fulfil the "Pompeii premise" embedded in such assumption. Although the hunter-gatherers of the late Holocene may not be substantially different from the ethno-historical reality, the time factor and the nature of the material evidence itself make such similarities far less persuasive in an explanation of archaeological patterns. The prehistoric records document the long term processes, measured in tens and hundreds of years, while the ethno-historical evidence represents short term operations, measured in days and weeks, rarely in years.

The archaeology of hunter-gatherers is essentially similar to natural history in its concern with population, measure of diversity and selection as the process of change (compare Leonard and Jones 1989). In both fields the Darwinian theory of evolution provides the general framework of reference and best integration between methods and theory. Since 'peculiarities inherent in cultural evolution are literally imbedded in the patterns it generates. [...] Darwinian theory is imbedded in data while seeking to explain it' (Rindos 1989:22). Therefore it is possible to view the study of prehistory as human natural history rather than more historically bent progress from a primitive stage to civilisation.

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APPENDICES

Table A1: Radiocarbon results and calibrated dates

laboratory number	radiocarbon date BP	calibrated dates BP				
Wk - 1731	860+/-65	946 (			759)	670
Wk - 1730	560+/-75	670 (	616,	612,	547)	500
SUA: 2683	430+/-110	670 (			509)	290
NZA 723**	273+/-70	510 (			306)	0*
BETA-31500	80+/-50	280 (	53,	42,	0*)	0*

0* represents a "negative" age BP; ** accelerator mass spectrometry result; Calibration by 'University of Washington Quaternary Isotope Lab Radiocarbon Calibration Program 1987 Rev. 2.0'

Table A2: Pilot sampling: raw materials (counts) for the sampling units ($1m^2$) within each assemblage (Fig. 21-22)

site		sqm	qt	qz	ct	sl	N	notes
1	A	A/-1	19	47	1	9	76	coll.
2	A	A/50/30	27	98	2	22	149	coll.
3	A	A/50/40	64	81	8	24	176	coll.
4	A	A/50/50	106	113	9	57	285	coll.
5	A	A/49/60	38	78	4	31	151	coll.
6	B	B/67/55	20	76	9	7	112	coll.
7	B	B/75/64	20	97	9	23	149	coll.
8	B	B/81/59	28	170	17	31	246	coll.
9	B	B/60/35	9	68	5	7	89	coll.
10	C	C/46/80	0	1	4	69	74	field
11	C	C/46/90	2	4	4	80	90	field
12	C	C/46/100	1	1	2	94	98	field
13	D	D/35/46	28	23	27	14	92	field
14	D	D/80/150	38	18	12	5	73	field
15	D	D/100/300	33	13	10	3	59	field
16	E	E/50/58	247	99	71	87	504	coll.
17	E	E/35/70	55	20	19	17	111	field
18	E	E/50/98	48	18	15	14	95	field
19	E	E/50/49	54	22	15	18	109	coll.
20	G	G/29/12	46	4	4	3	57	coll.
21	G	G/29/18	289	57	29	17	302	coll.
22	G	G/29/24	244	38	19	10	311	coll.
23	G	G/29/35	736	111	77	60	986	coll.
24	H	H/99/99	27	57	39	34	157	coll.
25	H	H/65/123	31	33	25	46	135	coll.
26	H	H/59/135	47	37	23	113	220	coll.
27	H	H/110/110	13	31	18	34	96	field
28	ST	ST-1	46	25	15	92	178	coll.
29	ST	ST-2	64	24	19	120	227	coll.
30	ST	ST-3	85	32	18	181	316	coll.
31	ST	ST-4	140	77	48	314	579	coll.
32	ST	ST-5	279	151	40	411	881	coll.

qt - quartzite; qz - quartz; ct - chert; sl - silcrete.
coll. - sample collected; field - sample measured in the field only.

Table A3: 245 sampling units ($1m^2$) analysed for intra-site uniformity and inter-site variability (Fig. 26). Raw counts are given for nine variables: quartzite (qt), quartz(qz), chert (ct), silcrete (sl), core (cor.), blade (bld.), scraper (scr.), retouched flake (ret.), and other tools (oth.).

site/sqm	qt	qz	ct	sl	cor.	bld.	scr.	ret.	oth.
1 A/55/-1	19	47	1	9	0	0	0	2	1
2 A/50/30	27	98	2	22	1	0	1	2	0
3 A/50/40	63	81	8	24	1	1	0	3	0
4 A/50/50	106	113	9	57	6	0	6	6	0
5 A/46/60	36	71	2	11	5	0	0	5	1
6 A/47/60	46	99	6	21	1	0	5	4	0
7 A/48/60	25	63	2	17	5	0	1	6	0
8 A/49/60	38	78	4	31	3	0	2	2	1
9 A/48/61	35	69	0	13	4	0	2	3	1
10 A/49/61	46	90	4	21	3	0	2	3	0
11 A/49/62	54	80	5	32	7	0	2	3	0
12 A/49/63	52	69	4	32	4	0	4	2	1
13 A/49/66	74	85	5	50	4	2	2	7	1
14 A/49/67	83	101	10	48	1	0	3	1	1
15 A/48/68	36	70	12	34	6	0	2	3	1
16 A/49/68	42	51	6	30	2	0	2	1	1
17 A/46/69	47	41	4	18	4	0	4	5	0
18 A/47/69	53	50	10	40	0	0	6	6	1
19 A/48/69	51	49	9	41	6	2	6	7	0
20 A/49/69	69	106	18	78	3	1	5	5	0
21 B/60/30	13	87	6	27	5	4	2	1	1
22 B/61/30	25	119	10	31	2	0	5	2	0
23 B/62/30	21	115	11	30	0	1	2	5	1
24 B/63/30	22	139	11	34	4	2	4	3	0
25 B/64/30	38	223	19	53	6	0	1	7	0
26 B/65/30	26	122	11	58	3	2	6	3	1
27 B/66/30	43	128	25	34	1	2	4	2	0
28 B/67/30	17	95	14	43	4	1	3	5	0
29 B/68/30	16	114	7	28	2	2	1	2	0
30 B/69/30	30	104	17	34	0	1	0	4	1
31 B/60/31	11	118	8	23	3	3	5	6	5
32 B/61/31	21	166	4	35	1	2	2	1	0
33 B/62/31	27	115	14	41	3	2	3	1	3
34 B/63/31	29	195	17	52	4	3	5	10	4
35 B/64/31	38	135	12	42	3	3	0	5	3
36 B/65/31	34	224	7	59	2	5	5	3	8
37 B/66/31	31	135	8	47	1	1	4	11	2
38 B/67/31	20	148	11	27	0	0	2	5	0
39 B/68/31	24	113	13	41	2	0	2	6	0
40 B/69/31	55	291	37	95	9	5	8	24	9
41 B/60/32	17	83	13	22	1	2	2	3	0
42 B/61/32	20	104	6	22	7	2	2	5	0
43 B/62/32	36	140	12	52	2	4	1	6	1
44 B/63/32	18	165	21	47	1	3	2	1	0
45 B/64/32	33	182	15	63	4	2	3	8	1
46 B/65/32	33	176	25	38	3	4	2	8	2
47 B/66/32	18	177	16	45	4	2	6	6	0

Table A3: cont.

	site/sqm	qt	qz	ct	sl	cor.	bld.	scr.	ret.	oth.
48	B/67/32	34	159	13	33	0	1	4	6	1
49	B/68/32	31	197	15	64	5	6	6	7	1
50	B/69/32	44	199	21	77	6	3	4	14	1
51	B/60/33	13	41	3	18	1	0	1	5	2
52	B/61/33	7	122	8	21	2	0	1	4	1
53	B/62/33	15	85	5	19	0	2	2	3	0
54	B/63/33	21	136	15	36	3	2	3	2	3
55	B/64/33	14	105	16	31	2	0	4	8	0
56	B/65/33	34	212	19	46	2	3	5	7	0
57	B/66/33	23	160	22	33	1	2	2	5	0
58	B/67/33	23	103	19	35	0	2	2	5	0
59	B/68/33	28	175	11	48	4	4	2	4	0
60	B/69/33	23	99	7	43	0	2	2	3	0
61	B/60/34	3	79	1	16	0	3	0	1	0
62	B/61/34	17	83	8	18	1	0	0	3	0
63	B/62/34	15	108	17	32	1	1	3	5	0
64	B/63/34	17	149	26	27	2	2	4	3	2
65	B/64/34	22	109	23	25	4	1	1	3	0
66	B/65/34	36	177	32	40	8	0	5	5	1
67	B/66/34	29	180	29	58	1	7	3	9	1
68	B/67/34	26	180	17	43	3	3	1	3	1
69	B/68/34	34	117	19	42	2	1	2	9	0
70	B/69/34	30	154	15	46	5	2	5	9	2
71	B/60/35	9	68	5	7	2	0	0	0	1
72	B/61/35	5	83	12	14	0	1	0	3	0
73	B/62/35	12	85	12	26	0	3	0	3	0
74	B/67/55	20	76	9	7	0	0	2	7	1
75	B/75/64	20	97	9	23	2	3	5	2	1
76	B/81/59	28	170	17	31	3	0	2	0	0
77	B/-100	31	104	7	8	5	0	2	15	1
78	C/62/54	0	0	0	22	0	0	0	0	0
79	C/63/54	1	0	4	69	0	0	0	1	0
80	C/64/54	2	4	4	80	0	0	2	2	0
81	C/65/54	1	0	4	67	0	0	0	1	0
82	C/66/54	2	1	5	47	0	0	0	1	1
83	C/67/54	1	1	4	57	0	1	0	1	0
84	C/68/54	2	0	2	37	0	0	0	0	0
85	C/62/55	1	1	7	67	0	0	0	3	0
86	C/63/55	0	1	2	79	1	0	0	1	0
87	C/64/55	2	0	1	50	0	0	0	1	0
88	C/65/55	0	1	1	64	1	0	0	1	0
89	C/66/55	0	3	1	52	0	0	0	0	0
90	C/67/55	0	1	3	53	0	0	0	1	0
91	C/68/55	0	3	1	28	0	0	0	0	0
92	C/62/56	0	0	4	77	0	1	0	2	0
93	C/63/56	0	0	2	61	0	0	0	0	0
94	C/64/56	0	3	5	77	0	1	0	1	0
95	C/65/56	5	2	4	102	0	1	0	1	0
96	C/66/56	2	2	5	45	1	0	1	1	0
97	C/67/56	0	2	6	41	0	0	0	0	0
98	C/68/56	1	1	5	33	0	0	0	0	0
99	D/44/63	24	13	11	4	1	0	0	0	0
100	D/46/63	13	3	6	2	0	0	1	0	0

Table A3: cont.

site/sqm	qt	qz	ct	sl	cor.	bld.	scr.	ret.	oth.
101 D/48/63	4	1	1	2	0	0	0	0	0
102 D/50/63	14	1	2	0	1	0	0	0	0
103 D/52/63	10	5	2	0	0	0	0	1	0
104 D/54/63	43	25	7	8	1	0	0	1	0
105 D/56/63	0	12	3	4	1	0	0	0	0
106 D/58/63	13	3	0	2	0	0	0	0	0
107 D/60/63	14	7	3	0	0	0	0	0	1
108 D/62/63	4	3	1	1	1	0	0	0	0
109 D/54/50	7	5	0	1	0	0	0	0	0
110 D/54/52	2	1	1	0	0	0	0	0	0
111 D/54/54	14	7	3	1	0	0	0	0	0
112 D/54/56	19	16	8	8	0	0	2	0	0
113 D/54/58	33	11	11	4	2	0	1	1	2
114 D/54/60	51	22	7	6	1	0	1	1	0
115 D/54/62	69	38	7	8	2	0	0	1	0
116 D/54/64	21	19	5	7	0	0	2	1	3
117 D/54/66	17	12	4	0	0	0	2	2	2
118 D/54/68	9	17	5	3	0	0	0	0	0
119 D/54/70	11	8	3	2	0	0	0	0	0
120 D/54/72	6	13	6	3	0	0	0	0	0
121 D/25/46	28	23	27	14	0	0	1	1	0
122 E/47/49	115	44	42	46	1	2	0	8	0
123 E/48/49	106	50	32	22	2	1	0	5	0
124 E/49/49	78	34	50	25	1	1	4	15	2
125 E/50/49	228	122	52	12	2	0	5	5	2
126 E/51/49	66	38	39	39	2	0	2	5	1
127 E/52/49	166	73	64	53	0	0	3	13	0
128 E/53/49	190	88	71	49	10	0	8	17	1
129 E/47/50	119	40	40	42	6	0	2	2	0
130 E/48/50	132	43	34	34	1	0	1	6	3
131 E/49/50	195	69	65	58	2	0	1	11	0
132 E/50/50	89	26	26	17	1	1	0	6	0
133 E/51/50	138	61	42	35	4	0	5	3	1
134 E/52/50	242	75	48	83	3	1	5	4	0
135 E/53/50	82	14	35	27	4	1	8	8	0
136 E/50/51	171	41	32	36	0	0	2	7	0
137 E/51/51	95	24	49	27	2	1	12	10	1
138 E/52/51	119	34	45	43	3	2	1	5	0
139 E/53/51	260	99	50	68	5	0	1	9	0
140 E/50/52	133	22	31	45	4	1	2	20	0
141 E/51/52	159	45	47	67	7	0	3	11	0
142 E/52/52	164	40	34	71	8	1	1	2	1
143 E/53/52	196	50	62	50	3	0	5	4	0
144 E/50/53	119	29	42	26	1	1	2	12	0
145 E/51/53	128	43	36	49	2	1	4	10	0
146 E/52/53	168	44	52	26	3	1	1	3	1
147 E/53/53	242	55	80	80	6	0	3	4	0
148 E/50/54	104	35	53	54	1	1	1	5	0
149 E/52/54	153	40	70	51	3	2	1	9	2
150 E/53/54	256	69	75	78	0	1	5	6	0
151 E/51/55	309	107	74	104	6	1	8	12	1
152 E/52/55	298	91	108	60	0	0	1	8	0
153 E/53/55	215	62	73	56	3	1	0	14	2

Table A3: cont.

site/sqm		qt	qz	ct	sl	cor.	bld.	scr.	ret.	oth.
154	E/50/58	247	99	71	87	10	3	9	19	0
155	E/50/95	54	22	15	18	0	1	0	0	0
156	G-1	63	14	8	7	0	0	0	1	0
157	G-2	43	7	8	2	0	0	0	0	0
158	G-3	90	17	18	2	0	0	0	0	0
159	G/29/6	3	0	0	0	0	0	0	0	0
160	G/29/10	20	0	1	0	0	0	0	2	1
161	G/28/30	468	57	56	29	2	3	4	8	4
162	G/29/30	515	54	39	26	4	0	3	11	5
163	G/30/30	656	81	102	58	7	2	10	9	5
164	G/28/31	307	40	26	22	4	3	4	16	3
165	G/29/31	527	66	63	38	12	4	6	16	1
166	G/30/31	740	122	82	66	6	4	1	13	8
167	G/28/32	396	56	54	24	5	1	1	2	4
168	G/29/32	614	90	94	37	7	3	6	13	5
169	G/30/32	651	93	57	60	4	4	7	12	4
170	G/31/32	781	73	109	35	3	3	3	12	2
171	G/28/33	489	80	57	33	2	3	4	12	6
172	G/29/33	756	90	80	56	7	3	3	25	6
173	G/30/33	667	83	89	37	5	6	5	13	4
174	G/31/33	851	98	112	37	4	6	8	11	3
175	G/28/34	697	97	92	34	6	1	3	12	5
176	G/29/34	677	84	96	41	6	5	7	12	7
177	G/30/43	565	63	60	48	1	1	2	15	4
178	G/31/34	764	86	75	63	3	3	6	11	2
179	G/28/35	701	82	71	54	2	3	2	18	6
180	G/29/35	738	111	77	60	3	0	3	14	1
181	G/30/35	503	61	82	30	3	2	2	12	5
182	G/31/35	852	86	113	35	2	5	4	23	2
183	G/29/12	46	4	4	3	1	0	0	3	3
184	G/29/18	289	57	29	17	4	0	0	8	4
185	G/29/24	244	38	19	10	6	0	2	7	4
186	H/95/90	41	65	51	76	1	2	0	10	0
187	H/96/90	12	21	48	57	1	0	4	5	1
188	H/97/90	53	77	81	76	1	1	2	6	0
189	H/98/90	68	56	66	59	1	1	3	5	1
190	H/99/90	42	56	54	59	3	0	0	6	1
191	H/95/91	55	38	52	90	2	3	3	10	1
192	H/96/91	15	12	60	25	0	1	1	4	0
193	H/97/91	42	46	79	55	6	2	2	2	0
194	H/98/91	69	60	101	84	3	1	0	7	2
195	H/99/91	18	9	53	29	3	1	0	3	0
196	H/95/92	64	45	96	103	3	2	7	10	0
197	H/96/92	59	36	54	83	3	0	4	9	3
198	H/97/92	77	84	92	112	5	2	3	6	1
199	H/98/92	53	49	55	47	1	1	1	2	0
200	H/99/92	29	28	36	48	2	2	2	9	2
201	H/95/93	55	51	78	57	1	1	7	11	1
202	H/96/93	94	121	116	147	12	1	6	11	1
203	H/97/93	46	39	52	47	5	1	1	3	0
204	H/98/93	30	44	47	42	0	0	1	1	0
205	H/99/93	40	101	28	103	6	5	0	3	1
206	H/95/94	67	110	86	98	1	0	5	8	0

Table A3: cont.

site/sqm	qt	qz	ct	sl	cor.	bld.	scr.	ret.	oth.
207 H/96/94	24	27	49	63	2	3	1	5	2
208 H/97/94	15	1	38	29	1	1	1	7	1
209 H/98/94	42	30	49	60	2	3	1	4	1
210 H/99/94	19	16	48	21	1	3	3	1	0
211 H/95/95	54	68	84	70	1	2	2	9	0
212 H/96/95	35	31	46	70	3	0	2	2	1
213 H/97/95	36	46	61	56	2	0	0	4	1
214 H/98/95	45	74	65	52	0	0	0	9	1
215 H/99/95	32	55	44	42	1	2	2	2	0
216 H/95/96	44	37	91	83	2	1	4	3	1
217 H/96/96	71	81	76	97	1	3	2	5	1
218 H/97/96	40	63	60	60	4	2	1	4	1
219 H/98/96	44	71	47	45	1	1	1	5	1
220 H/99/96	35	51	55	44	3	3	0	5	0
221 H/95/97	65	90	97	119	2	0	8	14	0
222 H/96/97	24	16	63	50	3	2	2	10	0
223 H/97/97	52	75	55	80	2	0	2	2	0
224 H/98/97	38	33	49	57	2	0	3	8	0
225 H/99/97	15	31	20	36	1	1	0	5	0
226 H/95/98	57	96	71	103	4	1	5	15	1
227 H/96/98	67	59	52	76	4	2	7	9	1
228 H/97/98	47	30	59	50	3	1	0	3	0
229 H/98/98	40	70	41	58	0	0	2	4	0
230 H/99/98	21	28	33	35	0	0	4	4	0
231 H/95/99	47	62	70	120	4	0	4	4	1
232 H/96/99	42	58	53	66	1	1	0	1	1
233 H/97/99	9	5	22	20	1	1	1	3	1
234 H/98/99	34	62	38	56	1	0	3	0	0
235 H/99/99	27	57	39	34	1	1	1	3	0
236 H/65/123	31	33	25	46	2	0	4	4	1
237 H/59/135	47	37	23	113	2	0	1	4	1
238 ST-1	46	25	15	92	0	1	0	2	3
239 ST-2	64	24	19	120	3	1	1	6	7
240 ST-3	85	32	18	181	2	2	2	5	3
241 ST-4	140	77	48	314	4	2	2	5	1
242 ST-5	279	151	40	411	5	2	6	10	4
243 ST-6	48	5	7	142	5	0	3	3	1
244 ST-7	38	9	5	80	1	0	2	8	0
245 ST/8	37	5	3	113	0	0	0	6	0

Table A4: Proportions of small and midium-size flakes; raw data.

	qt		qz		ct		sl		
	s	m	s	m	s	m	s	m	N
A	196	273	373	410	28	38	126	245	1689
B	329	450	3165	2677	368	257	709	968	8923
C	11	12	24	20	29	58	915	990	2059
D	813	1595	733	471	118	93	88	158	4069
E	1586	2248	788	615	738	563	428	625	7591
G	5930	4706	1003	506	950	460	443	317	14315
H	698	900	1210	971	1616	983	1030	1326	8734
ST	387	248	184	22	114	35	754	379	2123
							total		49503

s - small flakes; m - midium-size flakes

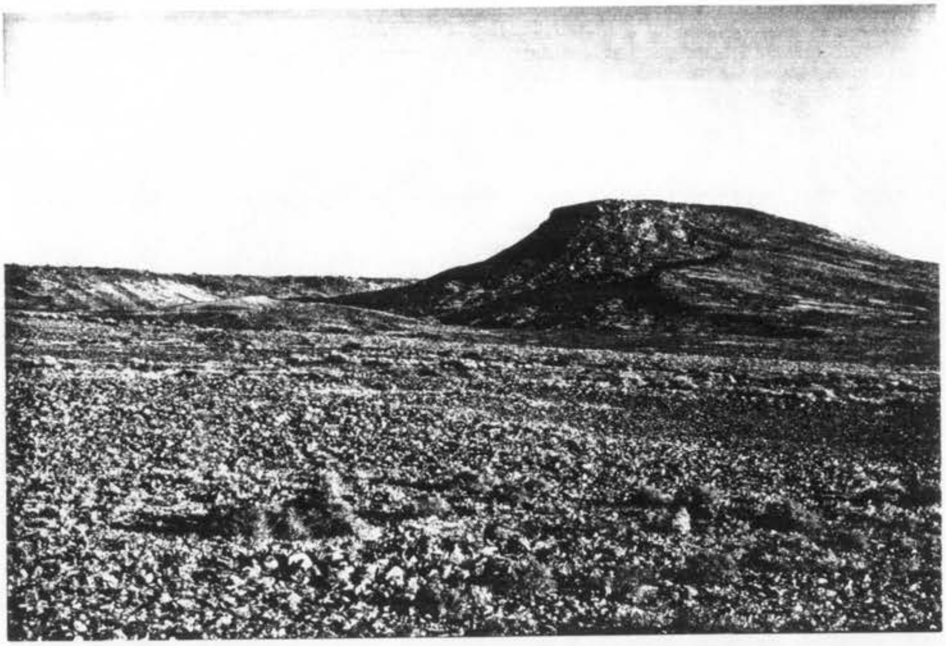

Photo 1. Typical landscape of the mound spring country: gently undulating gibber plains and small mesas capped with silcrete, calcrete or gypcrete crust.

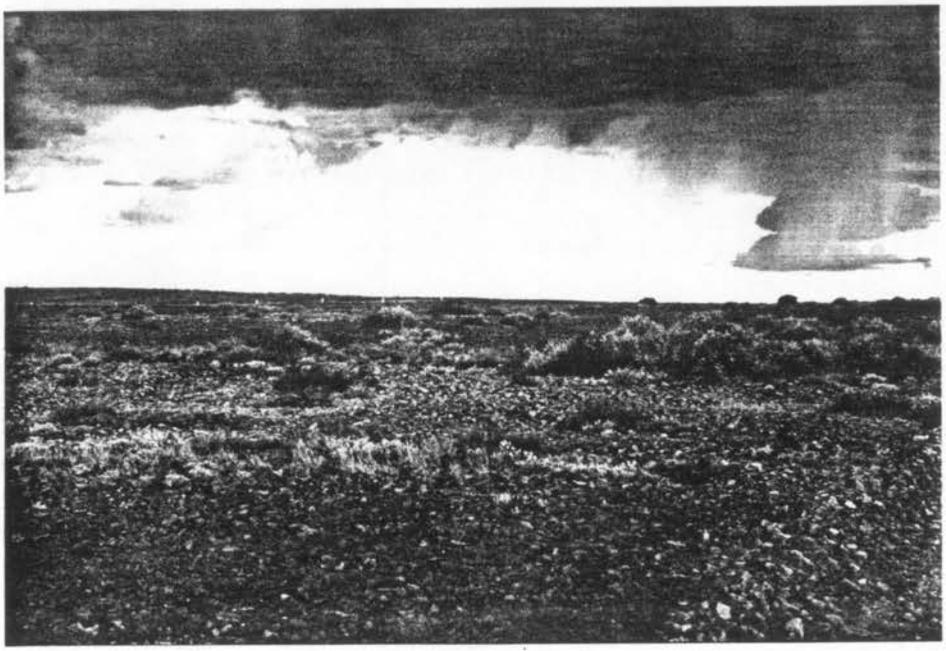

Photo 2. Some heavy clouds bring only light showers.

Photo 3. Spring with a small mound and a pool of water: Welcome Springs.

Photo 4. Small sand dune developed next to the mound spring: Old Woman Spring, site G.

Photo 5. R.J.Lampert showing one of the knapping workshops: Old Finniss.

Photo 6. Deflating sand dune; pails of sand trapped between the roots of dead shrubs indicate former dune surface: Old Woman Springs, site G.

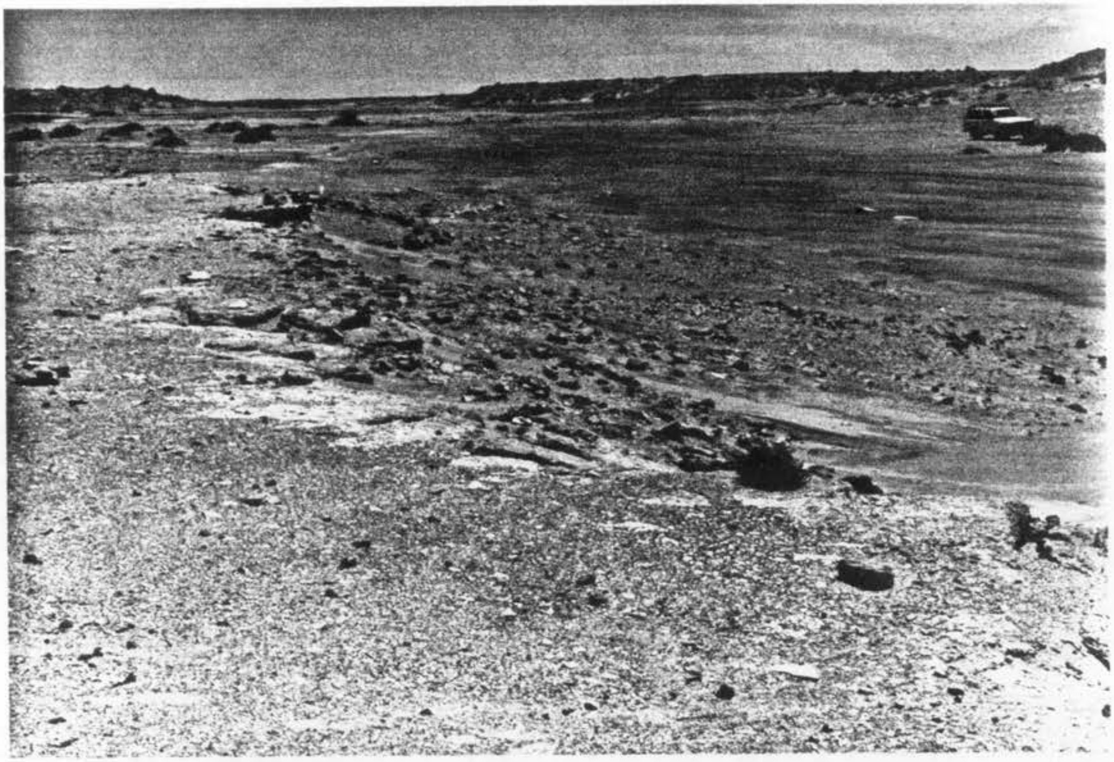

Photo 7. Breaking edges of the travertine plate: Welcome Springs, site B.

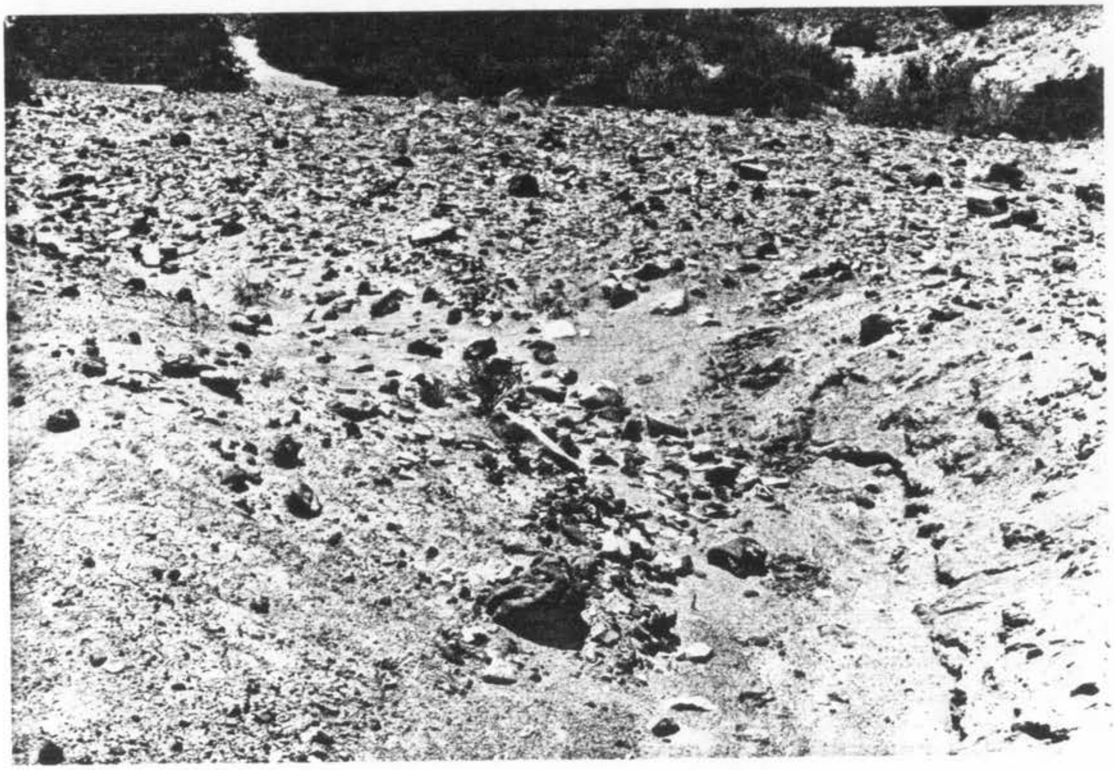

Photo 8. Deep gullies developing on the eroding slopes of site A.

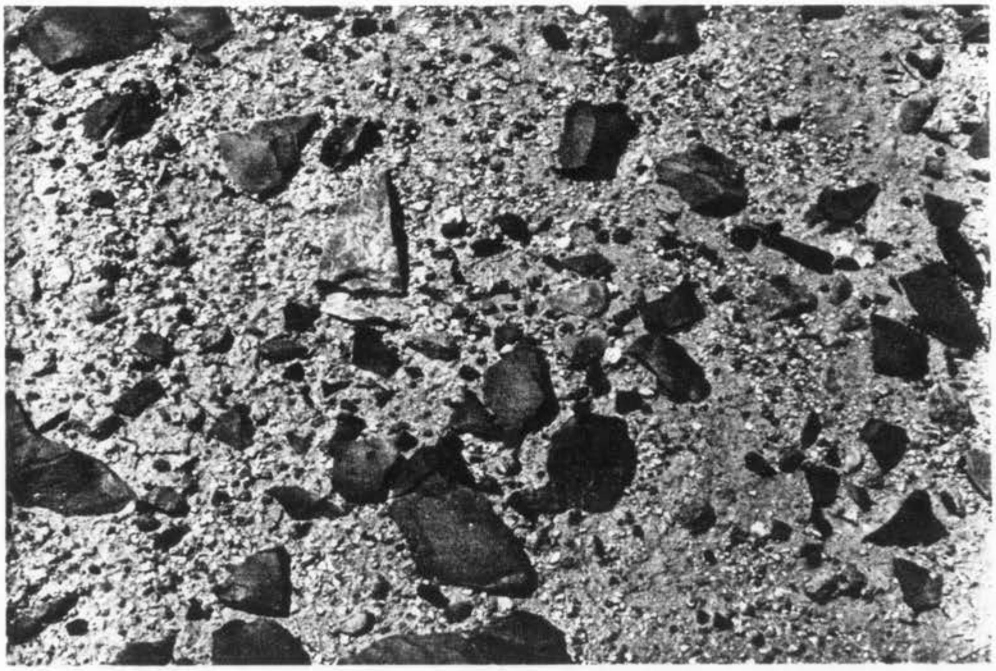

Photo 9. One of the isolated off-site knapping floors: Wangianna Springs.

Photo 10. One of the isolated off-site knapping floors: Davenport Springs.

Fig. A1. (p.322) Stone tool types referred to in this thesis: 1-3: tula and tula slugs; 4: pirri point; 5-7: backed blades (geometrics); 8-10: thumbnail scrapers; 11-14: scrapers; 15-17: retouched flakes; 18: grinding stone (base); after Cane 1992; McCarthy 1976; O'Connell 1977; White and O'Connell 1982; Smith 1986.

Fig. A1