Errata

Page 23 para 2, line 2 ’39 mammals’ should read ’39 mammal taxa’
Page 28 para 2, line 2 ‘predator’ should read ‘human predator’.
Page 29 para 2, line 2 ‘predator prey’ should read ‘hunter-prey’
Page 89 table 16 NISP % Total ‘100’ should read ’99.99’
Page 89 table 16 Wt % Total ‘100’ should read ’99.19’
Page 89 table 17 Wt % Total ‘100’ should read ’99.97’
Page 90 table 18 NISP % Total ‘100’ should read ’99.97’
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Page 91 table 19 NISP % Total ‘100’ should read ’99.96’
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Page 93 table 23 Wt % Total ‘100’ should read ’99.99’
Page 104 table 42 Unit 4 % Total ‘100’ should read ’100.28’
Page 136 para 1 lines 5-6 ‘22,000 bp to 20,000 bp’ should read ‘20,000 to 17,000 bp’
Page 152 para 1 line 3, ‘table 13’ should read ‘table 11’
Page 152 para 2, line 6, ‘on one’ should read ‘on the one’
Page 153 line ** ‘Cosgrove’ should read ‘Cosgrove et al.’
Page 160 para 5, line 1, ‘be’ should read ‘been’
Page 173, para 1 line 5 ‘illucidate’ should read ‘elucidate’
Page 196 line 16 insert ‘Bellwood, P. 1978 *Man’s Conquest of the Pacific*. Collins, London.’
Page 211 line 22 insert ‘Smith, A. and J. Allen, 1999 Pleistocene Shell Technologies: Evidence from Island Melanesia. J. Hall and I.J. McNiven, (Eds.) *Australian Coastal Archaeology*. ANH Publications, Canberra. pp. 291-297.’

TREES TO THE SKY: PREHISTORIC HUNTING IN NEW IRELAND, PAPUA NEW GUINEA

by
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This work is a thesis submitted for the degree of Doctor of Philosophy at the Australian National University

January 2004

Except where otherwise stated in the text, this thesis is entirely on my own research.

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ABSTRACT

This dissertation investigates the nature of prehistoric hunting strategies in New Ireland, Papua New Guinea. New Ireland contains the earliest radiocarbon determinations for human occupation and therefore provides an opportunity to investigate colonisation. It also has a depauperate fauna compared to New Guinea and therefore provides an opportunity to investigate subsequent human adaptations. Hunting strategies are investigated through an analysis of the Buang Merabak faunal assemblage. The Buang Merabak assemblage contains prehistoric food refuse including shell and bone midden material and stone artefacts. The results of the faunal analysis are interpreted to investigate issues of resource use, land use and mobility. Resource use is reflected through prey selectivity and provides the opportunity to investigate the nature of hunting specialisation as a mechanism of adaptation.

Prey taxa have discrete ecological requirements that are the parameters of their spatial distribution across the island. Notions of human land use are reflected through the spatial distribution of the prey taxa and are interpreted as a reflection of both on site and off site activities. In order to exploit each particular taxon the hunter must interact with the prey within the prey's environment. Therefore within the hunting context, human land use is reflected by the prey they capture and bring back to the site.

Mobility is reflected through resource use and land use. The spatial distribution of the prey taxa reflects the distance the hunter must cover in order to capture the prey and return to the site. In this context, mobility is notionally a relative scale that rates the degree of movement required to exploit the resources reflected in the assemblage. The results are brought together to suggest a New Ireland specific model of behaviour that can be tested against further research.

This dissertation argues that terrestrial faunas such as *Dobsonia* sp. bats and the *Phalanger orientalis* were an important aspect of the Late-Pleistocene subsistence economy in New Ireland.

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Chapter 1: Introduction

1.0 INTRODUCTION

Late-Pleistocene and Holocene colonisation and subsequent adaptation in New Ireland, Papua New Guinea (PNG) are the topic of this dissertation. The supporting data are drawn from a faunal assemblage excavated from the Buang Merabak cave site and engages with colonisation and adaptation through an investigation into hunting strategies within a cultural ecology and optimal foraging theoretical framework.

Professional archaeological research in New Guinea began with Sue Bulmer's (Bulmer, S.and R. Bulmer, 1964) excavations in the Highlands and in New Ireland with White (Downie and White 1978) and others (Peterson and Billings 1965). The single largest body of research occurred with the Lapita Homeland Project (Allen and Gosden 1991) and was ultimately the genesis of this project. The early archaeological investigations focused on the hunter/gatherer-agriculture transition (Golson 1977; Hope and Hope 1976) and only indirectly on notions of hunter-gatherer behaviour. Research projects that focused on hunter/gatherer behaviour favoured stone artefacts as their primary dataset although faunal remains were plentiful (White 1972). While faunal analysis is not new to archaeology (Dart 1957) its more recent application in New Guinea has produced a variety of results summarised in chapter 2 (Aplin 1981; Leavesley 1996; Leavesley and Allen 1998; Marshall and Allen 1991; Mountain 1991; Pasveer 2003; White et al. 1991; Williams 1997). Subsequent taphonomic studies of archaeological sites have also continued to progress and have brought the stratigraphic integrity of a variety of archaeological sites into doubt. Consequently, there are few sites in the circum New Guinea region with faunal assemblages that have undergone both extensive taphonomic and archaeological analyses making those that have even more valuable.

The relatively low quantity of research in the Bismarck Archipelago necessitates that first order questions are a priority. Therefore the objective of this dissertation is an investigation into colonisation and subsequent adaptations to the island environment. The adaptations are considered in four ways including resource use, hunting strategies, land use and mobility and are defined and discussed in turn below. Ethnographic studies indicate that hunter/gatherers generally had a broad based diet containing a large proportion of carbohydrate that was supplemented by protein. The theoretical framework has been tailored specifically to protein acquisition unless indicated.

1.2. THEORETICAL PERSPECTIVE

Resource use reflects the variety of human prey collected for consumption. New Ireland has a relatively depauperate environment compared to New Britain and New Guinea. Human hunter/gatherers can respond to the lower biomass in a variety of way. In terms of prey selection there are three possibilities to concentrate on a small number of relatively reliable resources, ie. a specialist strategy; to utilise a broad prey selection strategy to include all possible prey species, ie. a generalist strategy; or to utilise a combination of the above depending on the specific local circumstances. This dissertation utilises these concepts to determine whether Pleistocene hunters can be classified as generalists or specialists and whether their resource use changed over time.

Humans as predators make micro-economic decisions regarding participation in certain activities that increase the chances of hunting success over others. Hunting is a scheme of decisions designed to maximize returns and is therefore highly compatible with micro-economic theory such as optimal foraging. Hunting strategies are based on prey ecology and hunting ethnography. Different prey require different hunting techniques depending upon their specific ecological and behaviour characteristics. The taxa themselves have important ecological attributes and some individuals within specific taxa have behavioural traits that influence predator success. The hunting strategies outlined in this study are drawn from New Guinea's vast ethnography and investigated in order to distinguish between explicit technology and implicit knowledge. From this, hunting strategies specific to the New Ireland environmental context are proposed.

Land use analyses reflect which parts of the landscape were utilised for what purpose and how often. This is inferred through a combination of the ecological requirements of prey taxa and the hunting strategies discussed above. Hunting implicitly suggests that the hunter seeks out the prey in the prey's habitat. Each of the prey taxa potentially reflect ecological niches' within the environment. Some taxa are ubiquitous across New Ireland while others occupy more specific niches'. The niches' might include characteristics that are apparent at different temporal cycles including daily or seasonal behaviour. The combination of ecology and predator behaviour informs land use.

Mobility like land use is investigated through the combination of prey ecology and human micro-economics as expressed through hunting strategies (Gamble 1991:1). The rate at which the hunter must move across the landscape is dictated by the ecological characteristics of the prey in conjunction with the protein requirements of the predator. Mobility is considered in terms of relative movement over time and space rather than absolute time.

Cultural ecology and micro-economics as optimal foraging are the most appropriate theoretical framework for this study for two reasons. First, the unit temporal resolution does not provide a fine enough scale to identify short-term behaviour or events. The Units span several thousands of years each (see chapter 3) and are considered as an accumulation of individual events that cannot be teased apart. Secondly, Bismarck Archipelago archaeology necessitates first order enquiries that are most appropriately addressed at the broadest scale so as to avoid the prospect of over generalisation in the absence of vast quantities of evidence.

The long chronological units described for Buang Merabak in chapter 3 suggest that most changes were likely to have been gradual and evolutionary in nature (Allen 2000:143). Interpretations must be consistent with the units of time in which the results are presented. Therefore broad scale interpretations are most appropriate for broad scale units of time. The most appropriate theoretical framework for the units presented below is based in ecology because it is most conducive to interpretations based in this temporal framework. This chapter describes the cultural ecology theoretical framework within which optimal foraging theory is based. The approaches adapted here are ultimately born out of research whose beginning might reasonably be marked by the *Man the Hunter* conference (Lee and De Vore 1968) that emphasized human adaptations to the environment. Subsequent research has emphasized that hunter-gatherers had, and have, a dynamic spectrum of ways of responding to circumstances (Foley 1999:116). This is particularly exemplified by faunal exploitation and has been interpreted in relation to a diverse array of behaviours such as resource use, land use and mobility (Marean and Assefa 1999).

This dissertation takes a cultural ecology theoretical perspective which is itself based in evolutionary theory. Evolutionary change is defined in terms of the selection of particular optimal traits within an ecological framework that are conducive to breeding advantage.

1.2 Cultural Ecological Theory

Krebs and Davies (1981) define behavioural ecology as the study of the survival value of behaviour. Behaviour is the response to the requirements of the ecological conditions in which humans live (Foley 1987:65) and therefore key aspects of hunter-gatherer economy are ecological in nature. The principles of ecology are intimately bound to the theory of evolution because it is natural selection that in the long term shapes ecological relationships through differential reproductive success (Foley 1987:50) and therefore human responses can be modelled using general ecological principles (Stiner 1991:4). Biological evolutionary theory focuses specifically on human adaptation (Gould 1998) while cultural ecology theory places human adaptation in terms of the material environment (Johnson 1999:144). The ecological conditions provide the parameters within which humans live (Winterhalder 2001:10). In terms of protein procurement all environments contain more species that are edible to humans than can be effectively harvested by them (Winterhalder 2001:12-14). Mobility can be predicted based on the general ecology of an area (Gamble 1991:5) because different ecological conditions almost certainly result in different human behaviour (Marean and Assefa 1999:34). Given these variables, cultural ecological theory explains human behaviour through micro-economic theory and micro-evolutionary processes (O' Brien and Lyman 2002:34).

Cultural ecological theory places concepts drawn from micro-economic theory into an ecological context by viewing the ecology as an important part of the economy (Jochim 1976; Mithen 1990:140; Winterhalder 2001:14). Micro-economics reflect the relationship between supply and demand at the individual level. Cultural ecology considers both the overall carrying capacity of a landscape and the risk associated with specific exploitative schemes (Johnson 1999:145). Therefore, it can be measured in a number of ways including the scheduling of time required for specific tasks (Torrence 1983). Cultural ecology also allows the focus of research to engage meaningfully with questions reflecting short-term variation. In particular, it encourages investigation into the applicability of uni-directional models, suggesting an evolutionary movement from simple to complex to be tested in an archaeological context (Foley 1999:115-116).

Cultural ecology has also been criticised on the grounds that it transfers present contemporary notions of economy onto the past (Johnson 1999:146; Shanks and Tilley 1987). The ‘formalists’ consider that economics, as they are understood in the Western tradition, reflect the tension between supply and demand, a notion that does have universal validity (Johnson 1999). This is because humans have an evolved economic disposition derived from past economic relationships between humans as predators and prey (Alvard 1998:62; Hirshleifer 1991). The 'substantivists' retort that contemporary theories of economics are not applicable to the past (Sahlins 1972). Bettinger (1991:105) responds that the substantivist alternative of *norms* is less adequate because it is descriptive. An alternative approach to countering the criticism might be the contextualisation of each case in which economic theory is utilised. Notionally, this can be achieved by investigating each assemblage as an isolated incident focusing on the specific details of each context, in order to determine their environment and then accounting for the behavioural differences with direct reference to the context within which it occurred. This dissertation takes the position that the basic economic decisions regarding the human desire for food are a universal and therefore the basic economic principles reflecting supply and demand are applicable across time and indeed species.

Cultural ecology theory has also been criticised on the grounds that the prehistoric environment itself was constructed from a Western scientific perspective (Johnson 1999). The critics perceive Western science as Western centric and imbued with a specific cultural perspective placing it hierarchically above other cultural perspectives rather than along side them. Certainly, all contemporary archaeology reflects its requisite intellectual context and constraints. However, the universal requirement for sustenance cannot be denied even when contemporary notions are used to define it.

Humans do not allocate resources in the most efficient manner every time and therefore why expect subsistence efficiency from foragers? There are four responses from the behavioural ecologists to this question. First, competitive interactions in relation to shared resources such as food, mates or space are key factors in determining behaviour (Foley 1987:50). Secondly, Winterhalder (2001:32) describes subsistence efficiency as a response to the evolutionary adaptation of the prey taxa to (constant) predation and vice versa. Human predators must have been efficient enough to keep up with taxa that were changing their (anti-predation) defence mechanisms, reflecting a kind of symbiotic growth in the development of the predator-prey relationship. Thirdly, part of the human hunting strategy is to learn (more) about the life-ways of their prey. It is a desire to learn, and to be a better hunter, that is interpreted as a reflection of the hunter's desire to be more efficient (Winterhalder 2001:32). Fourthly, protagonists prefer the view that economic strategies are sensible and effective in their own context (Winterhalder

2001:33). It is not difficult to consider specific economic concepts as universal even accepting that we coin them explicitly in terms of Western thought. Additionally behavioural ecological models can be tested, to some extent, in the ethnographic literature (Winterhalder 2001:33) and therefore can be refuted on evidential grounds depending upon their applicability (Winterhalder and Smith 1992).

The usefulness of cultural ecological theory lies in the fact that hunter-gatherers live within an environmental framework upon which they are dependant for vital resources including food and shelter and for this reason the environment is a strong force in shaping hunter-gatherer adaptations (Bettinger 1991:77). The ecology provides the physical parameters within which people collected food. Human social and cultural behaviour, seen from either a positivist or relativist perspective, occurred within the same environmental parameters and therefore cultural ecological theory provides a useful framework in which to investigate human behaviour.

Cultural ecological theory models how hunter/gatherers might respond to certain conditions and is often underpinned by optimal foraging theory or constrained optimisation (Winterhalder 2001:31-33). Optimal foraging suggests that humans will select the path of least resistance and constrained optimisation reflects the fact that any given choice is constrained by the limitations set by its specific context.

2.2.1 Optimal Foraging Theory

Optimal foraging theory examines the costs and benefits associated with different activities. Human adaptation has a tendency to optimise the possibilities given within the environment in which we live. It is the attribute of selection, derived from evolutionary theory, that favours the optimal solution for the problems faced by an organism (Foley 1987:63).

Optimal foraging theory is utilised to generate expectations about the spatial distribution of sites and alternative interpretations of data (Keene 1983:140), assuming that people made rational economic decisions. As people seek to attain several simultaneous goals from their behaviour, ease or efficiency of food getting will be important, but efficiency in other departments may be equally important or indeed provide conflicting goals as optimal models may differ significantly from real decisions (Jochim 1983:159-160). Optimal foraging theory outcomes can be calculated in a number of ways including energy (Keene 1983:140), time (Torrence 1983) or opportunity cost. These provide important insights into subsistence change and the relationships between human impacts on the environment and human responses to their environment (O'Brien and Lyman 2002:34). Optimal foraging theory models have been applied in three primary areas:

- Food choice and dietary consumption (resource use);
- Group organisation and site location (land use);
- Resource distribution and patch use (mobility) (Keene 1983:139).

The unit of analysis for optimal foraging theory is the community as an accumulation of individuals. Genes flow from parent to child while customary knowledge and traditions flow from generation to generation (Keene 1983:141-142). In this context the community is considered as an aggregate of individuals (Keene 1981). The creation of a baseline of behaviour (using optimal foraging theory) can be achieved if the underlying goal(s) of the model are in fact the same as the goal(s) of the people involved (Jochim 1983:165).

The behaviour modelled with optimal foraging theory depends not only on the goals of the model but also on the procedures of variable definition, measurement and a combination of both. A negative correlation between the optimal foraging theory model and the observed data might represent optimal foraging in conjunction with other unidentifiable social or cultural factors rather than simply a non-optimal method of selection. In addition to micro-economic issues of supply and demand, optimal foraging theory may also reflect other criteria such as subsistence security (Jochim 1983:164-165). Security over a resource in the long-term might make it more attractive than the short-term gains associated with switching resources and it can be factored into an OFT model if considered appropriate.

A major limitation of optimal foraging theory is that only optimal data are explained. It sets the data into a dichotomous position of either being optimal or non-optimal. Optimal foraging theory tends to ignore the non-optimal behaviours (Jochim 1983:166; Keene 1983:146) and is limited because it does not account for degrees or hierarchies of importance. For instances, decisions are made on the basis of many influences including social, political, economic and religious factors. Decision-making is the culmination of rating (consciously or unconsciously) the relevant criteria and accepting the opportunity cost of the outcome. The ranking of the criteria reflects a hierarchy of importance for a given decision. The flexibility of optimal foraging theory to include non-economic criteria within the decision-making process is extremely limited. It is however not impossible if the criteria can be assigned a quantifiable value. For instance, if a set of data is dissimilar to the optimal model then it might be interpreted as optimal within given ethnographical defined social or cultural constraints.

Economic theory is not value free. The concepts and terminology of economics come from a modern western tradition and may not be applicable to prehistoric world-views (Keene 1983:148). Bettinger (1991:105), by asserting that optimal foraging theory is about behaviour rather than cognition, suggests that it must be tested on behavioural rather than cognitive grounds and the former is more directly reflected through the material culture than the latter. For example, the acquisition of food in any given form is fundamental to all living things and can therefore be considered to have universal importance that reaches beyond western conceptualisation.

Economic models are argued to be teleological meta-narratives in that they include expectations of outcomes that do not reflect the diversity of practical experience on the ground and they arbitrarily separate economics from other parts of human behaviour (Bettinger 1991:105). Micro-economics reflect the relationship between supply and demand on an individual level. It is teleological in that humans instinctively require sustenance and therefore they will necessarily obtain food in order to survive. The way in which humans do this is necessarily a reflection of a combination of social, cultural and economic processes. However, rather than being a meta-narrative, micro-economic theory provides a framework within which the social cultural and economic milieu, that is human behaviour, can be described.

Optimal foraging theory relies on uniformatarian principles because it is dependent upon observations of living organisms made in the ethnographic present. Hypotheses are written within a micro-evolutionary scale and applied to the temporal dimensions of the archaeological record that are typically observed at macro-evolutionary scales (O'Brien and Lyman 2002:34). This can be overcome by using frameworks that are consistent in both contexts and will necessarily confine the scope of any conclusions to the relatively broad scale.

Having established that information reflecting the nature of the natural environment is helpful in understanding the parameters in which prehistoric hunter-gatherer behaviour occur a theoretical link is required between contemporary observations and archaeological data. The assumption followed here is that certain environmental characteristics that exist today, following uniformitarian principles, also existed in the past. The emphasis is on the transposition of environmental observations as enunciated through cultural ecological and optimal foraging theory.

Lastly, the word 'optimal' implies maximum economic utilisation that is, in fact, not ever achieved in contemporary developed economies. The problem here is one of definition. In hunter/gatherer studies optimisation is defined as adaptation in response to a base-line of survival. Prehistoric foragers need only to increase rather than maximise their foraging efficiency (Mithen 1990:17).

The theories and models generated from behavioural ecological theory and optimal foraging theory provide a yardstick of objective economic rationality that is used as a basis for the comparative study of human behaviour. They are extremely useful because they provide a framework in which the crucial questions relating to resource use, land use and mobility within relative large temporal units can be usefully investigated. While social, political and religious criteria cannot easily be factored into economic models, the result of the decision-making process in which they play a part can be identified within the archaeological record.

2.2.2 Resource Use

Resource-use, or selection, can be predicted based on the encounter-contingent model that reflects the micro-economics of opportunity cost. Decreasing encounter rates with highly ranked (optimal) prey species will result in the broadening of the species that are considered in the optimal set. Conversely, increasing encounter rates with highly ranked species progressively narrow the range of resources selected. Equally if a resource is outside the optimal set then increased encounter rates will not necessarily move it into the optimal set (Winterhalder 2001:16).

Resources can be used in a variety of ways depending on the requirements of a given community. In this dissertation resource use refers to the degree of focus on individual prey taxa during hunting, on a notional continuum from specialist and generalist. The distinction can be conceptualised in at least three ways in relation to the social division of labour, hunting technology or the product of hunting. First, the social division of labour reflects the division of chores or activities between different elements of the community. If a segment of the human population within a community spends a disproportionate amount of time on one activity then they might be considered to be specialists. This may occur along age, gender or hierarchical lines and may be specific to an individual. The second concept reflects the division between different levels of technological input into hunting practices. If a disproportionate amount of time is allocated to the production and implementation of a specific set of hunting techniques, this might be categorised as the use of specialist technology. And thirdly, hunting might be specialised in terms of its specific focus on factors such as the diversity of prey taxa, prey size or age. The following discussion refers to specialisation as defined in the terms of prey selection.

The faunal assemblage is the product of hunting and foraging and therefore reflects predator choice of some description. A predator who selects a low range of prey might be described as a specialist hunter while a predator who selects a wide range might be considered a generalist. Humans can typically survive on a broad diet, that is to say, they can adapt to eating a wide variety of prey including cannibalism (Bjerre 1957; Lawrence 1964) and are therefore not limited to a narrow diet to survive. Even in a faunally depauperate environment the human hunter is ecologically equipped to survive on almost anything available. Within the New Ireland context, the human hunter might be considered a specialist if he selects one taxon, or a group of taxa over the other available taxa, or alternatively, a generalist if he preys upon all available taxa equally.

For instance, ethnographic reports illustrate a hunting group whose focus is the targeting of pigs but along the way they also encounter smaller taxa such as rodents (Hide et al. 1984:297). Rather than leave the smaller taxa the hunter will/may capture them as they go about their task of pursuing the pigs. The product of the exercise will be the capture of the non-target and target taxa. The result is that statistically there will be a greater percentage of the target taxa relative to the non-target taxa captured. Therefore, the catch of a specialist hunter might be expected to include a range of taxa while being dominated by only one or two.

2.2.3 Hunting Strategies

Hunting strategies are the methods of prey capture. They are drawn from the ethnographic literature within the circum New Guinea region. The hunting strategies below are explored in order to identify the range of potential strategies for the capture of any given prey. They also suggest methods of prey capture requiring the lowest level of inherent technology. The ethnography serves to identify the link between the prey represented in the archaeological assemblage and the processes that led to their capture and is therefore important to archaeology (Gamble 1991:2). The hunting strategies provide a link between the assemblage and models of land use and mobility.

2.2.4 Land Use

Optimal foraging theory provides a useful framework in which to investigate land use as a reflection of resource distribution. The distribution of land use can be predicted if the behaviour and habitat of the prey taxa are known. Hunter/gatherers will select the prey that provides the highest benefit for the least cost. Selection will depend on the relationship between the number or size of the prey and the energy required to capture them. In selecting prey the hunter may choose between collecting a greater number of small prey species or a lesser number of larger prey species. The selection will reflect the combination that provides the greatest benefit for the least cost. A high-density 'resource patch' is a zone or place that has a relatively higher density of resources compared to its surroundings. For example, the annual seasonal migration of millions of the *Agrotis infusa* (Bogong moth) to a relatively small number of the high peaks of the eastern highlands in the Kosciuzko National Park (Flood 1980:61-62) reflects a high-density resource patch. Predators are attracted to resource patches because the high density of the resource increases the likelihood of predatorial success. Within a high-density resource patch return has an inverse relationship to time spent at the patch. In accordance with optimal foraging theory, the first resources selected from the patch will be those of the highest quality requiring the least output of energy. Foraging will proceed in line with a cost/benefit ratio in which the quality of what is collected reduces while energy expenditure increases until energy output exceeds the returns (or costs exceed the benefits). Put another way, the longer the forager spends at a patch the lesser the returns. A hunter/gatherer will nearly always depart a patch before it has been fully depleted as the costs of staying and expending energy to catch the last individual out-weighs the cost of moving to the next resource patch. An incidental consequence is that hunter/gatherers leave behind breeding stock that allows the resource population to recover (Winterhalder 2001:17).

2.2.5 Mobility

Mobility reflects the rate at which people move across the landscape and is described in terms relative speed. It can be understood in a number of ways depending upon its context. Residential mobility refers to the frequency of movement between base camps (Sahlins (1972) while hunting mobility refers to the frequency of movement during the hunting process. Once a base camp is established by a human social group, high residential mobility suggests that they spend relatively little time there before moving onto the next base camp location. It does not necessarily presuppose that base camp locations are predetermined. Hunting mobility reflects the degree of movement that occurs for the purpose of protein collection within the hinterland of, and to and from, any particular base camp (Binford 1978; 1980).

Mobility can also be seen as a reflection of foraging efficiency. It is directly influenced by the local depletion of a resource and the travel costs of reaching more distant and less depleted zones. Camps will move more often if (1), relocation costs are cheap, (2) depletion of the zone immediately around the occupation camp is rapid and/or (3) alternative residential sites offer high initial rates of return (Winterhalder 2001:22).

In addition to resource accessibility there are a number of other factors that influence mobility. Mobility has a direct relationship to portability (Winterhalder 2001:30) in that all long-term possessions must be easily transportable. This then has repercussions for the collection and storage of resources. The group with the lowest number of possessions will be able to move quicker and more often.

In the search for food increasing encounter rates (reducing traveling time) and lessening search costs increase efficiency. A forager moves more quickly through an environment with dense and rich resources, taking less from each encounter (Binford 1980). Alternatively, if the resources occur at a low density across the landscape but in high density at specific isolated nodes on the landscape then mobility will be high between the resource patches.

2.3 Optimal Foraging Theory and the Modeling of Prehistoric Behaviour at Buang Merabak

The approach outlined above, which utilises cultural ecological theory in conjunction with optimal foraging theory, is the most appropriate method for Pleistocene/Holocene archaeological interpretation. The relatively long chronological units periods temporally situated well beyond contemporary cultural connections coupled with the relative paucity of artefactual material preclude the use of socially oriented theory. Optimal foraging theory is better suited to this dataset because it reflects broad behavioural models that are more suited to the low-resolution data and is likely to explain more of the observed material record than alternative approaches.

Within this framework human resource selection is reflected by the relative quantity of each taxa in the assemblage. Hunting strategies can be investigated because each taxa have specific idiosyncratic biological and ecological characteristics that are more amenable to some hunting techniques rather than others. Land use is reflected by the spatial distribution of the prey selected by the human hunters. The relative quantities of each prey taxa reflect which prey were pursued and therefore which environmental niches were visited by the hunters. Lastly the specific population densities of the prey taxa suggest the optimal mobility strategy for successful predation.

3. DISSERTATION STRUCTURE

Having provided the theoretical perspective, the rest of the dissertation is organised into eight chapters. Chapter 2 discusses the geomorphological and environmental background to the region in order to illustrate the environmental characteristics that form the parameters within which humans adapted. Chapter 2 also summarises the regional archaeological context upon and within which this dissertation is based. Chapter 3 describes the background to the Buang Merabak cave site including previous excavation methods and results and those utilised for this analysis. It culminates with the presentation and discussion of the temporal units developed for this analysis. Chapter 4 presents the results of the faunal analyses describing the assemblage in terms of the presence and absence of individual taxa through both quantitative and qualitative analyses. Chapter 5 differentiates between cultural and natural depositional processes. It describes the methods of data collection. Chapter 6 presents an interpretation of the results for the pre-Last Glacial Maximum Pleistocene Units (4 and 3) at Buang Merabak in terms of resource use, hunting, land use and mobility. Chapter 7 presents an interpretation of the results for the Pleistocene/Holocene transition and Holocene Units (2 and 1) at Buang Merabak in terms of resource use, hunting, land use and mobility. Chapter 8 discusses the changes that occur between each of the units and presents a model of behaviour for New Ireland, concluding with a summary of regional human behaviour on the basis of the theory described in chapter 1.

Chapter 2

Environmental Context and Archaeological Background to the Bismarck Archipelago and Solomon Islands.

1. INTRODUCTION

Hunting reflects a complex interplay between the predator, prey and their environmental context. A variety of models have been proposed for the colonization and subsequent human adaptations in the Bismarck Archipelago and Solomon Islands that had implications for hunting strategies. The models suggest that hunters were dependant upon the geology, geomorphology topography and biota of the region (Allen et al. 1989; Allen and Gosden 1996; Enright and Gosden 1992; Gosden 1995). In this chapter the geology and geomorphology describe and explain the landscape evolutionary parameters that affected prehistoric behaviour in New Ireland. The zoology provided an overview of the New Ireland taxa that had previously been identified as potential prehistoric prey taxa and emphasize aspects of the taxa's behaviour that may have had implications for prehistoric hunters. The archaeological background emphasizes a number of the Late-Pleistocene and Early-Holocene behavioral models and the gaps therein. The last section briefly describes the nature of Lapita in New Ireland and environs for the purposes of providing a regional context for the Late-Holocene behaviour at Buang Merabak. This chapter emphasizes the faunal analyses particularly as they relate to hunting in the Pleistocene and Early-Holocene in New Ireland, Papua New Guinea and Near Oceania with particular emphasis on resource use, hunting strategies, land use and mobility.

2. NATURAL HISTORY

The Bismarck Archipelago and Solomon Islands are located off the east coast of New Guinea and New Ireland is the second largest island in the Bismarck Archipelago (see figure 1). Many of the archaeological models for New Ireland and the Bismarck Archipelago and Solomon Islands were based on evidence drawn from the region's natural history, in particular the geology, geomorphology, topography, environment and fauna and are described below.

2.2 Landscape Evolution

New Ireland's geological history indicates how it came to be an off shore island of Sahul and some of the implications. As part of the break up of the Gondwana super-continent 95 million years ago, Sahul (the greater Australian continental block including modern day Australia and PNG) began to move northwards into warmer tropical and subtropical latitudes. During the past 1.8 million years there were at least 17 distinct glacial-interglacial cycles, each of about 100,000 years duration. The interglacials were short-lived, occupying only 10% of each cycle. The amplitude of near surface air temperature change from glacial to interglacial was on average 5°C-10°C and often within the time interval of only 10,000 years. The last 7 glacial maxima

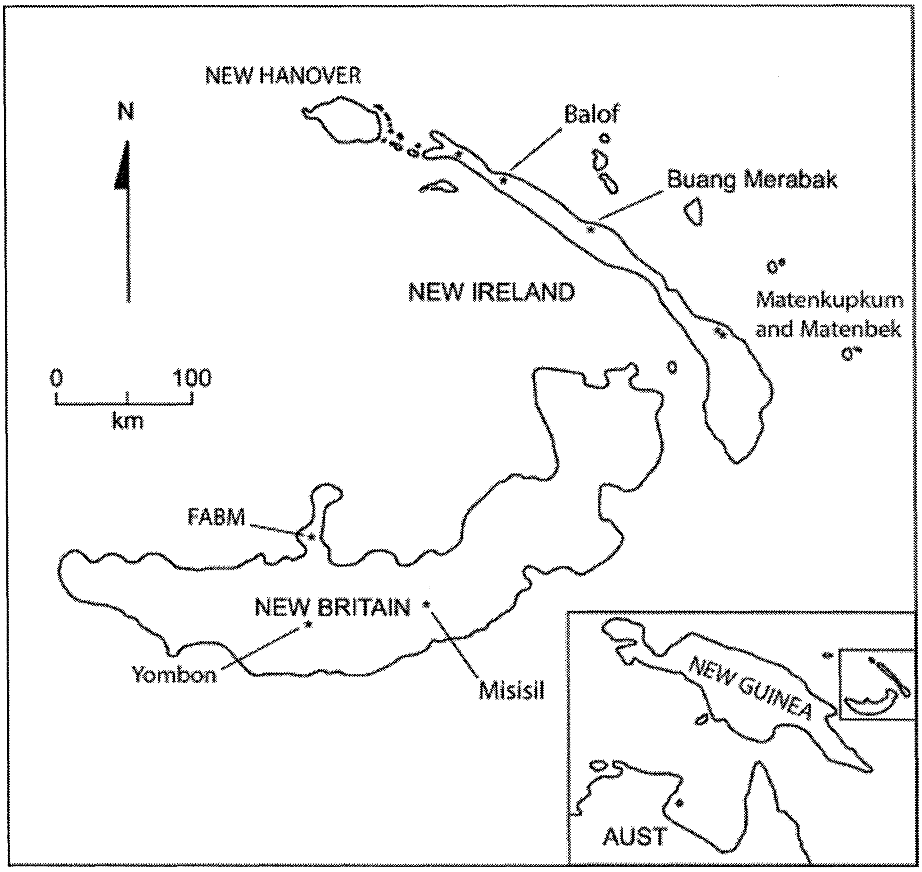

Figure 1: The New Britain and New Ireland Pleistocene archaeological sites.

were broadly similar in terms of global ice volume and sea level lowering (Veevers 1984:42). New Britain and New Ireland have been off shore islands of Sahul since at least the beginning of the Pleistocene and probably longer. The water bodies between them have been effective barriers to species distribution into the Bismarck Archipelago resulting in a relatively depauperate fauna compared to New Guinea.

The Last Glacial Maximum occurred between 32,000 bp and 14,000 bp with a central tendency at 18,000 bp (Lambeck and Chappell 2001). During the Last Glacial Maximum sea level was between 150-200 m lower than at present (Veevers 1984:47). Compared to today it was a time of relatively colder dryer and windier conditions. In New Guinea diminished precipitation was not likely to have been a major factor limiting plant growth although lower average temperature probably was (Veevers 1984:45). The pollen cores indicate, however, that climatic factors were not the only influence on vegetation patterns, and there was good evidence that humans were igniting fires and thus encouraging the spread of the New Guinea Highlands grasslands beginning at 21,000 bp and continuing at least until 8000 bp (Haberle 1993:117).

At 19,000 bp the sea level began to rise slowly and average precipitation was higher (Lambeck and Chappell 2001 *cf.* Veevers 1984:47). Ice retreat from the New Guinea glaciers except the Carstenz Mountains was accompanied by a temperature increase of 5-10°C culminating in a 1000 m upward shift in vegetation belts (Veevers 1984:47) at around 15,000 bp. At 10,000 bp the sea-level was 50 m below today (Spriggs 1997:45) and at 9000 bp the land bridge between Australia and New Guinea was severed for the last time. In contrast to the LGM, the 9000 bp, post glacial maximum temperature spike, was a time of mild climate and was slightly warmer than today. The present sea level was reached at 7000 bp to 6000 bp in Sahul (Thom and Chappell 1977) after which fluctuations were no more than 1 m discounting tectonic effects. The Bismarck Archipelago climate fits within this broad description but also has specific differences, as described below.

The geology and geomorphology have a direct impact on New Ireland's environment and biota and provided the parameters within which human hunters operated. In central New Ireland the Oligocene Jaulu volcanic are overlain by the Miocene Lelet Limestone that forms the Lelet Plateau. The Jaulu volcanic formed during a period of volcanism at the end of the Oligocene ca.

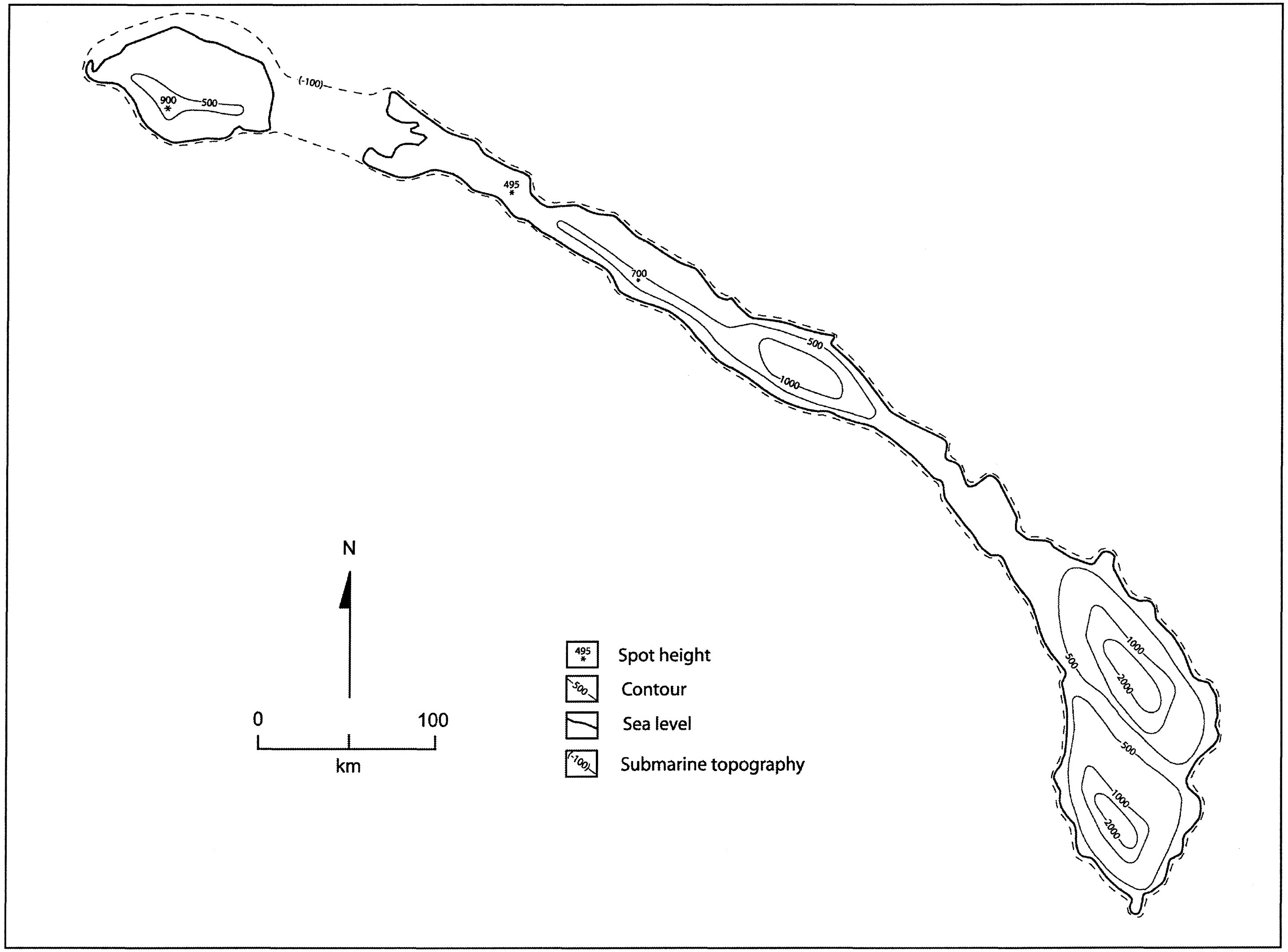

Figure 2: New Ireland topography

25 million years ago. Deposition of the Lelet Limestone began in the early Miocene ca. 15 million years ago and continued through the Miocene ceasing in the Pliocene, 5 million years ago (Veevers 1984:111; Stewart and Sandy 1986).

The Lelet Limestone is a series of transgressive fringing coral reefs that are exposed on the northeastern side of the Lelet Plateau as a series of 14 terraces. The youngest terraces are exposed near the present-day sea level and are successively older with height (Hohnen 1978:10) extending to 1480 m above sea level (see figure 2). They have a vertical spacing on average of 100 m and are typically preserved for several kilometres. At the base of the sequence the limestone consists of extensively re-crystallized coral (Folk 1961). In all but the uppermost beds biogenetic modifications have resulted in a massive almost structure less white limestone (Hohnen 1978:11).

The geology has important implications for topography. Rocks have different long-term reactions to climate depending upon their geochemical composition. The map figure 2 illustrates the topography of New Ireland at 500 m contour intervals and includes selected spot heights. The Lelet Plateau located in central New Ireland marks a significant alteration between the topography of the north and south. The south is very steep and high while the north is relatively lower and flatter. From Konogusngus Village the Lelet Plateau rises in a series of cliffs at a gradient of 18 m/m to over 1000 m, 18 km southwest as the crow flies. North of the Lelet Plateau the Schleintz Range has relatively lower topography grading to vast swamplands at Balgai Bay. The north east coast has the most extensive coastal plains anywhere in New Ireland. Within this region, Mount Kiding is 495 m asl, and 6.5 km from Lemakot village at a gradient of 0.07 m/m, significantly less than the Lelet Plateau. While this is only one example it is indicative of the terrain. South of the Lelet Plateau the coastal plain becomes increasing narrower (with the exception of the area of Namatanai Township) and the increasing rugged terrain has gradients equal to or greater than that of the Lelet Plateau.

The Lelet Limestone, typical of massive limestone in wet climates, contains extensive karst topography including caves and underground streams (see figure 3 for the distribution of limestone in New Ireland). Caves are common because the limestone has a much greater solubility

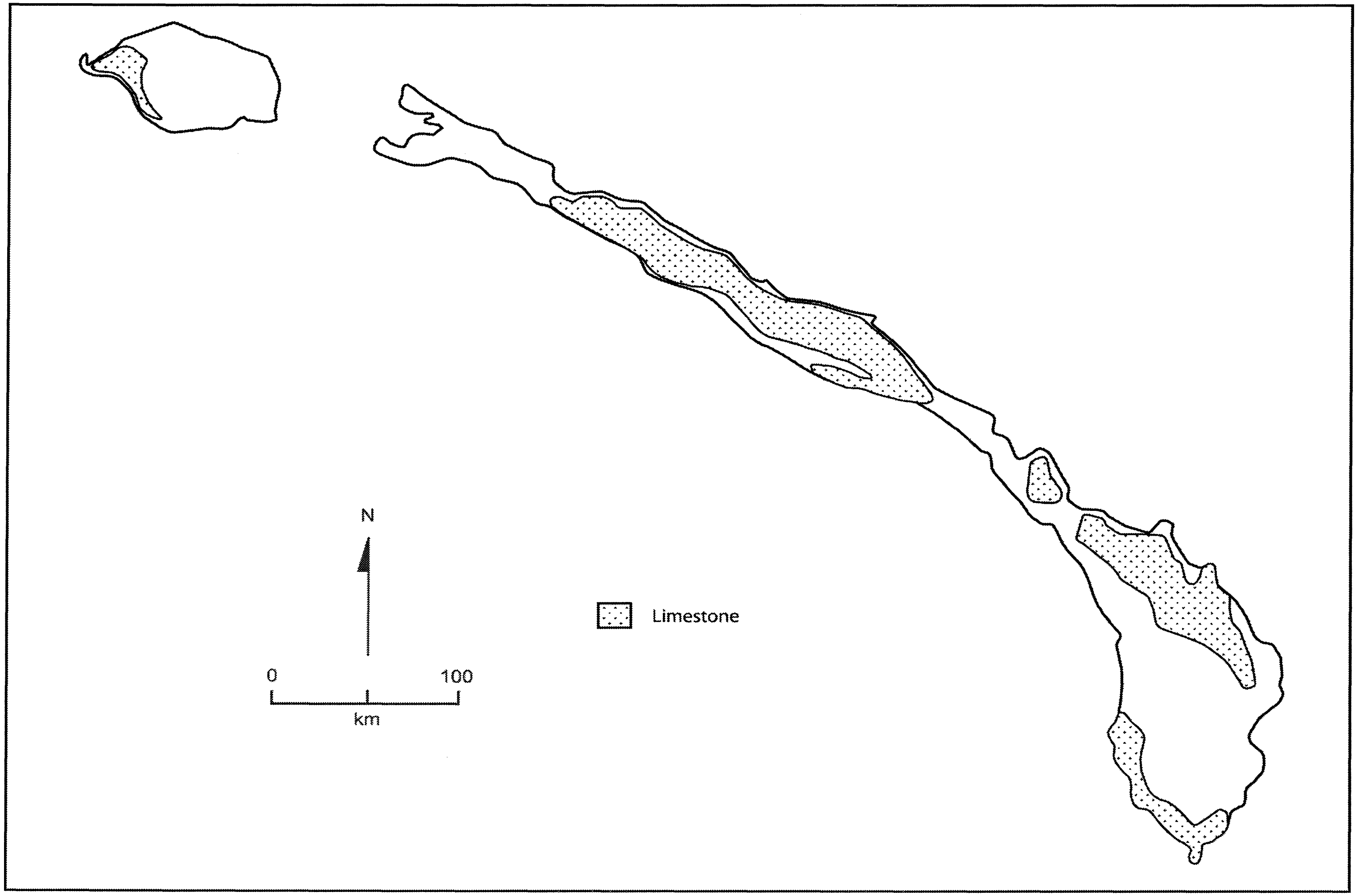

Figure 3: The distribution of limestone in New Ireland following Hohnen (1978).

than other rock types and solution is the dominant weathering agent. The actual process of weathering depends on the variety of limestone. Some limestone is dense, massive and of very low porosity, and solution is concentrated along joints and bedding planes and gave rise to true karst topography. Layers of secondary carbonate may form at or near the surface of soft limestone, forming a hard layer known as calcrete or caliche (Ollier and Pain 1996:56). New Ireland has a developed karst topography complete with many characteristic caves. For the coastal region between Kavieng and Muliama speleologists reported 70 caves that are relatively easy to access (Bourke and Gallasch 1974:204) and report that "there must have been many thousands of caves in the Schleinitz Range" (Bourke and Gallasch 1974: 202). The karst topography has implications for modelling human hunting behaviour because it influences the distribution of resources and can provide barriers to human predation.

The topography, as a product of geology and geomorphology, influenced the distribution of animal resources that have specific ecological requirements. Some taxa inhabit specific altitudinal ranges or utilise plants that only exist above or below a certain altitude. These potential prey therefore have a distribution that was limited by topography. Also certain ethnographic hunting strategies (see below) are more appropriate on flatter ground rather than rugged ground.

2.3 Bismarck Archipelago Environment.

In addition to topography, climate and ecology are the environmental variables that form the parameters for both the human predator and prey in the Bismarck Archipelago. The Bismarck Archipelago follows the broad environmental oscillations of northern Sahul but also has some of its own regional peculiarities. It is located between 2°S and 6°S of the equator and had a tropical environment throughout the Pleistocene. Volcanic activity has had a major impact in the Bismarck Archipelago. Several ash falls have been reported as emanating from Mount Witori in central New Britain and the earliest tephra was deposited just after 14,310 bp (Machida et al. 1996; Torrence et al. 2000).

Ar^{40}/Ar^{39} dating indicated that in Rabaul volcanic activity began 500,000 years ago producing successive events at 190,000 bp, 125,000 bp, 100,000 bp and 40,000 bp. Late-Pleistocene volcanic events occurred at 37,000 bp, 20,000 bp, 17,000 bp, 16,000 bp and 15,000 bp. ^{14}C

dating suggests Holocene events occurred at between 7000-3500 bp and 1400 bp and at least 8 intracaldera eruptions since 1400 bp. In more recent times volcanic eruptions occurred in 1767, 1791, 1850, 1878, 1937 and 1994 (Nairn 1995). During the 1994 eruption, ash reached the vicinity of Buang Merabak and had an impact on the local economy by covering many of the subsistence gardens. Elsewhere, volcanic events have been interpreted as a causal factor in the depopulation of the landscape and are therefore important to consider in this context (Torrence et al. 2000).

The lowering sea level of the Last Glacial Maximum had a limited impact on New Britain and New Ireland. The submarine topography of the latter is remarkably steep so the distance from a given coastal location was never far off the coast as the crow flies (Marlow et al. 1988). A reduction of the sea level during the glacial maxima had its greatest impact on New Hanover and the Tigak Islands because the sea level in this area had a maximum depth of less than 100m (Marlow et al. 1998). At the Last Glacial Maximum the sea floor was exposed as the Tigak Plain and northern New Ireland is connected to New Hanover forming 'Greater New Ireland'.

The changing sea-level had very little impact on the New Ireland biota. Although it may be significant at higher altitudes (such as the Lelet Plateau and Hans-Meyer Range) and latitude much of the lowland coastal vegetation was the same as today (Enright and Gosden 1992). While little was explicitly known about New Ireland's vegetation history, Hope (pers. comm.) reports a pollen analysis from Balof rockshelter in northern New Ireland (back to the early Holocene). The study found that it was difficult to determine the nature of the local environment because Chiroptera that roosted in the rockshelter foraged for vast distances beyond the local environment. Therefore, only a general view of the regional environment was ascertained. In the Lowelak swamp in northeastern New Ireland sedge build up including high quantities of charcoal suggests significant forest clearance occurred over the last few thousand years (Hope et al. 1999:394). Further research is necessary to obtain a better understanding of New Ireland's flora because it provides the diet for the herbivorous taxa that are the human prey.

2.4 New Ireland Fauna

The New Ireland fauna provides the parameters within which hunters selected prey. Hunting strategies require a degree of knowledge of the prey's ecology and behaviour in order to be successful. The major prey taxa are described below in order to provide their ecological characteristics.

As distance eastwards from New Guinea increases, species richness for all terrestrial taxa tends to decrease (Enright and Gosden 1992:162). New Ireland had a relatively depauperate range of taxa compared to New Guinea, a different variety to New Britain and a slightly wider range compared to the Solomon Islands (Flannery and White 1991; Flannery 1995). Tropical rainforests have a relatively high biomass supporting dispersed (rather than herding) taxa that tend to utilize the rainforest canopy in greater numbers than the ground. In particular they contain a variety of Aves, some of which have been identified in the archaeological assemblages as extinct (see table 1). The low density of taxa and their preference for the canopy was the greatest limitation for hunters (Bailey et al. 1989; Headland 1987; Headland and Bailey 1991).

Table 1: Previously identified Aves from Buang Merabak SQ2B (Steadman et al. 1999).

Class	**Order**	**Family**	**Species**	**Common name**
Avian		Ardeidae	*Eggretta sacra*	Pacific Reef Heron
			Nycticorax caldonicus	Rufous Night Heron
		Bucerotidae	*Aceros plicatus*	Blyth's Hornbill

Table 2: Taxa identified in the Buang Merabak (TP1A and TP1B) assemblage.

Class	**Order**	**Family**	**Species**	**Common name**
Mammalia	Diprotodontia	Phalangeridae	*Phalanger orientalis*	Cuscus
		Macropodidae	*Thylogale browni*	Pademelon
	Chiroptera	Pteropodidae (Megapteroptera)	*Pteropus neohibernicus*	Great Flying-Fox
			Dobsonia anderseni	Andersen's Bare-Backed Fruit Bat
			Dobsonia praedatrix	Bismarck Bare-Backed Fruit Bat
			Rousettus amplexicaudatus	Rousette Bat
			Nyctimene albiventer	Tube-Nosed Bat

		Nycteridae		
		(Micropteroptera)	*Hipposideros diadema*	Diadem Horse-Shoe Bat
		Rhinolophidae	*Rhinolophus megaphyllus*	Eastern Horse-Shoe Bat
	Rodentia	Muridae	*Melomys rufescens*	Black-Tailed Melomys
			Rattus praetor	Large Spint Rat
			Rattus exulans	Polynesian Rat
			Rattus sanila	*extinct Rat
	Artiodactyla	Suidae	*Sus scrofa*	Pig
Reptilia	Sauria	Varanidae	*Varanus indicus*	Mangrove Monitor
	Squamata	Scinidae	*Eugongolus* sp.	* (possibly extinct skink)

New Ireland had few large terrestrially based predators. Papua New Guinea had two taxa from the family Crocodylidae. They were *Crocodylus novaeguinae* which was known in New Guinea only and *C. porosus* that was extant across most of Melanesia. *Crocodylus* sp. primarily inhabits the mangrove forests and rarely, but occasionally, goes far into the inland forests (Webb et al. 1983). Therefore, humans were the only truly terrestrial mammal predators on New Ireland.

Pleistocene New Ireland contained a variety of land-based taxa with potential value as protein resources. These consisted of 39 mammals (see table 2) including cuscus, a pademelon, bats and rats and a variety of lizards, snakes and birds (Flannery 1995:418). The dominant taxa in the archaeological assemblages across New Ireland are: *P. orientalis*, *Dobsonia* sp., *Thylogale browni, Pteropus* sp. and species from the families Rodentia and Reptilia.

2.4.2 Phalangeridae

Historically New Ireland had two Phalangerid cuscuses. Phalangerids are generalist folivores allowing them to occupy a broad range of habitats (Montague 2000:10). Analyses of taxa within the family Phalangerids indicate they have a home-range, for males, of 1.9 ha (0.37 to 3.4 ha) and for females of 1.3 ha (0.6 to 2.7 ha) and this may be broadly comparable for the New Ireland taxa. Juveniles have a relatively large dispersal distance (Montague 2000:25). Twenty to 30% of juveniles disperse in the four months before their first birthday after they are sexually mature (Montague 2000:30). The *P. orientalis* first appears in New Ireland at 20,000 bp while

Spilocuscus maculatus is a modern introduction (Heinsohn 1998) and therefore will not be discussed further.

P. orientalis has a grey to brown pelage colouration, prominent ears, and a naked prehensile tail and grows to about 2 to 3.5 kg. It is not a seasonal breeder (Flannery 1993:175; 1995:99) but has a twelve month breeding cycle (Flannery 1993:175). It is nocturnal with a wide distribution centred on the lowland forests of northern New Guinea and its land-bridge satellites. For its distribution see: Laurie and Hill (1954; Carter *et al.* 1945; Flannery 1995; 1995; Menzies 1991). *P. orientalis* is predominantly an arboreal inhabitant of strand forest, coconut plantation, and the edges of mangroves as well as in swamp and rain forests of New Irelands interior. *P. orientalis* are known to shelter in tree hollows (George 1973:421) such as *Barringtonia asiatica* and *Calophyllum inophyllum* that overhang the beach and the sea at high tide (Heinsohn 1998) and sometimes to sleep on exposed branches, and have occasional bouts of diurnal activity (Heinsohn 2000:245). *P. orientalis* has a generalist diet (Flannery 1993:175) consisting of foliage and fruit and is an opportunist insectivore. The dental formula for *P. orientalis* is:

- Upper dentary: I^1 to I^3, C^1, P^1, P^3, M^2 to M^5;
- Lower dentary: I_1 I_2?, P_3, M_2 to M_5 (Archer 1984:706; Flannery 1995:440);
- Dentary eruption sequence: I1 & M2, M3 & M4 erupt first, followed by P3, then M5.

Assuming that New Ireland was in the past as it is in the ethnographic present, it would have been primarily covered in rainforest. *P. orientalis* would have been found in both the inland and coastal regions. Presently, it is found on the small off shore islands of the Anir, Tanga and Tabar Groups and also New Hanover. The habitat and therefore the distribution of *P. orientalis* might reasonably be considered to include all of New Ireland and many of the small off shore islands.

P. orientalis is unique among New Guinea's marsupials in that it usually bears twins (Flannery 1993:175; Heinsohn 1998:82). Animals aged between birth and 11 months are vulnerable to hypothermia and starvation. During its first 12 months the juveniles travel on their mother's back (Flannery 1993:175). Older animals are likely to be injured during capture and are susceptible to 'capture myopia' (Flannery 1993:175). While there are reports of predation of *P.*

orientalis by *Haliaeetus leucogaster*, the sea-eagle, (Heinsohn 2000), it is unlikely to impact on population size if it occurs at all.

2.4.3 Phalanger orientalis Hunting Ethnography

That *Phalanger orientalis* were "easily" (Wallace 1962 [1869]:301) captured in a variety of ways is reflected in the ethnographies from circum New Guinea cited below. A common trait of the methods was an intimate knowledge of the prey's ecology and behaviour.

In Bougainville, "[p]ossum hunting is an adventurous outing. Two or more boys or men equip themselves with 'camping' provisions-packets of sago and large numbers of betel chewing supplies and remain for two or three days in the forest capturing the little marsupials. After one is treed, sometimes with the assistance of dogs, a younger man will climb the tree and shake it down while his companions wait on the ground to pounce on the stunned animal. Occasionally, a live animal is brought home for a ceremony but more usually are killed, eviscerated, cleaned and smoked soon after capture. Liver, heart and blood are promptly eaten, while the smoked carcass is usually put aside for later consumption. Possum hunters appear not to mind the short rations and rough living of the chase, but the Siwai's characteristic uneasiness about tree-climbing is apparent despite the climbers' bravado. The Siwai also set ingenious but rarely successful traps for possums by rigging a trip-noose over a possum trail, a thick vine stretched between two likely trees" (Oliver 1973:57). Snares designed specifically for the capture of cuscus have been reported from Buin and Tanga (Anell 1960:100). The 'besetting' method was also common (Bulmer 1968:310). Alternatively, animals that live in tree hollows are in some cases difficult to extract and capable of injuring the hunter. Smoke may be used to force them out (also described for Australia by Anell 1960: Plate II) or hooks or pointed sticks can be used (Bulmer 1968:311).

P. orientalis does not make a nest but sleeps in hollow trees. "It eats many kinds of fruit and leaves, and is typically encountered in mated pairs, accompanied by one or two young, resting in tree branches in the day and even on the ground and hence they are often taken in pairs" (Morren 1989:125).

Ethnographic reports from the Maluku Islands in Eastern Indonesia reveal that the local population had detailed knowledge of the cuscus, especially in regards to sexual differences, age-development, habitat and behaviour. A variety of hunting and trapping techniques were utilised and air rifles were often preferred (Latinis 1996:20-23) and this was also true for the Melpa in the Whig Valley (Gerick and Panetta 1989:81). The scarcity of air rifles resulted in the frequent use of hardwood bows and arrows as they were considered to be the traditional weapon of choice for cuscus hunting (Latinis 1996:20-23). The use of bow and arrows is also reported from Kairi in the Papuan Gulf (Rhoads 1980:41). Men generally explored good hunting locations during the day and went back at night where they waited and listened for the prey (Latinis 1996:20-23; Rhoads 1980:41). A flashlight was often used to temporarily blind the cuscus and locate the target. The cuscus was then shot with the air rifle or arrow. Similarly, wooden clubs were used to beat a cuscus that has fallen or been forced from a tree. Dogs often accompanied a cuscus hunt but were generally not actively used in the pursuit (Latinis 1996:20-23).

Diurnal and nocturnal hunting practices differed considerably (Gerick 1991:241). During the day hunting was undertaken in combination with other activities. The preferred method was to spot a typical cuscus resting place (generally in the fork of a tree). A young male would climb the tree, grab the cuscus by the tail and dash it against the tree. If the tree could not be climbed the hunters would attempt to shoot the cuscus. The latter method was generally considered less successful. Night hunting was not generally associated with other activities and almost exclusively involved the shooting of the prey with air rifle or bow. Hunters also attracted cuscus by mimicking their calls. Traps and snares were also used for hunting cuscus (Ellen 1972:229). In New Guinea, a sapling ladder was used to climb the tree on a moonlit night and wait in ambush for the cuscus (Latinis 1996:25). Hide et al. (1984) reported from the Kalama country 56 of the 63 surveyed captures were made in trees, and only seven on the ground, usually aided by dogs. Thirty-two of the arboreal captures were shot with arrows in night ambushes, eight were shot by day, ten taken from tree holes, and a further six by hand. A great majority (21 of 28 cases) of ambushes were made in *Lithocarpus celebicus*; five others were made at *Ficus* sp. and one each at *Piper* sp. and *Bruismia* species. Trees from which animals were taken from holes included *Elmerrillia papuana*, *Canarium* sp. and *Cunonicae*. Other trees in which animals were shot by day included *Lauraceae* and *Dillenia* species. Trees from which specimens were taken by hand included *Cedrela* sp., *Ficus* sp., *Castanopsis* sp. and *Planchonella* species. Five mature animals were weighed, ranging from 1.13 to 2.4 kg (mean 1.6, S.E.M. 0.26). A juvenile female captured in association with a mature female weighed 0.6 kg. (Hide et al. 1984:338-339). Exploration for lair sites is a common practice during daytime hunting forays (Hide et al. 1984:298). Alternatively a group of men may fell a tree containing the cuscus and then club it to death (Rhoads 1980:41).

2.4.4 Hunting Strategies- Summary

P. orientalis and other taxa in the family Phalangeridae were captured by a variety of methods. All the ethnographically recorded hunting strategies occurred in the rainforest and included a working knowledge of the ecology and behaviour of the family Phalangeridae. The most common methods include combinations of preliminary investigation, stalking, ambush and the use of projectiles and did not include the capture of more than one or perhaps two (mother and dependant infant) at a time.

2.4.5 Thylogale browni

Another important prey species is the *T. browni* which until recently was considered a subspecies of *T. bruni* and consequently most of what is known about it is derived from the latter. It is a ground dwelling Macropod that inhabits forest zones and is thought to prefer secondary forest or grasslands. *T. browni* has an altitudinal range from sea level to over 1000 m in New Britain (Flannery 1995:83) and by extrapolation in New Ireland. It is known to have existed in New Ireland in historic times and has been reported (to the author during 2002 fieldwork), to exist on New Hanover. However, it probably never existed on any of the smaller islands in numbers large enough to support anything more than short-term human predation. Therefore, after its introduction, its habitat was likely to include all of New Ireland. Its usual method of escape from a predator is to hop through the bush at high speed.

The New Guinea *T. bruni* reportedly seldom stray far into thick forest (Hide et al. 1984:349 *cf.* Flannery 1995; White 1972) although "is widely found throughout the eastern two-thirds of New Guinea in forest and upper-alpine grasslands. White (1972) suggests that it does not inhabit lowland savannah. It probably breeds throughout the year and is thus able to adapt fairly easily to new habitats" (White 1993:174). Of 10 wallabies caught in a study by Hide et al. in

Simbu Province, 5 were male, 4 were female and 1 was unidentified. Three of the females each had a single pouch young (Hide et al. 1984:349).

2.4.6 Thylogale browni Hunting Ethnography

"Captures were made while patrolling: two animals were shot with shotguns, and seven were taken with the aid of dogs (either run down and killed by dogs or located by dogs and then killed with arrows)" (Hide et al. 1984:349). The wallaby is commonly caught by way of a chase that commonly follows on from stalking ambush or besetting and is commonly extended to include the use of dogs (Bulmer 1968:311).

The primary capture avoidance attribute of *T. browni* is its speed and agility across the ground. The predator can outsmart the prey in one of two ways. If the hunter can either, out run the prey in a chase or outsmart the prey by stalking or ambushing perhaps by the use of a projectile. The use of projectiles is limited in the thick vegetation of the rainforest although not impossible if it is allied with stalking or ambushing.

2.4.7 Chiroptera

All the New Ireland *Pteropus* sp. bats forage and roost in trees. They can occasionally be seen on or near the ground if they are feeding on fruit such as pawpaw or banana (*Musa* sp.). *Pteropus* sp. forage very widely and will commonly fly over the sea (although to what extent is not clear). Therefore, their distribution includes all of New Ireland and they are commonly found in fruit trees or roosting in the canopy.

There are two *Dobsonia* sp. within New Ireland and they are *D. praedatrix* and *D. anderseni* (Flannery 1995:418). The mean average male weight is 245-258 gms (n=5). *D anderseni* is a large species related to *D. magna* and *D. moluccensis,* but the only one with white feet. It is easily confused with *D. praedatrix* but upon close inspection differs in pelage and dentition. Observations suggest *D. praedatrix* most commonly roosts in trees while *D. anderseni* roosts in caves (Flannery 1995: 190).

The following information is derived from observations of both *D. anderseni* and Highlands *D. moluccensis* but is considered broadly comparable on the grounds that they are similar enough to have previously been considered as one species (Bergmans and Sarbini 1985). "The bat is active nightly around Miyanmin settlement around 1000m, feeding on ripe papaya and banana but seems to roost at higher elevations" (Morren 1989:130). Throughout the year it is a noisy nocturnal feeder on cultivated bananas and pawpaw (Hide et al. 1984:350-351). *D. anderseni* roost in the twilight zone of caves and is a common resident in New Ireland in large colonies and is known to inhabit shallow caves (Bonaccorso 1998:87; Smith and Hood 1981). In the Highlands, *D. moluccensis* roosts in caves in large numbers, in small groups in hollow trees and individually in such trees as bananas. It is also possible that roosting outside of caves is more common during the dry season (Hide et al. 1984:350-351).

2.4.8 Chiroptera Hunting Ethnography

The ethnographic literature is instructive because it provides important information pertaining to the predator prey relationship. It includes insight into predator strategies designed specifically for individual prey taxa and exemplifies the utilization of technology and the exploitation of particular prey weaknesses.

Megapteroptera can be captured in a number of ways both while roosting and on the wing. Anell (1960:64) describes the Qunantuna of New Britain using nets stretched out between two trees and Morren (1989:129) describes the use of bows and arrows in order to catch bats on the wing. Anell also reports how bats are smoked out of caves. Dwyer (1982:539) describes *D. moluccensis* being captured in caves where females aggregated with nursing young (Hide et al. 1984:351).

Reports of the Kairi in the Papuan Gulf indicate that "...the exploitation of flying-foxes and birds living in the high canopy posed special problems which have greatly diminished since the introduction of the shot gun. Today the hunter only need sight the game and fire. Before contact, procurement techniques were complex. Flying-foxes were only available during the rainy season 'when their sleep is deeper' and they were unaware of men felling the tree in which they roosted" (Rhoads 1980:41).

"At the Longul and Ogbi hamlets (in the Jimi-Yuat Valley), the most common prey were bandicoots and flying-foxes because of their ease of capture. Flying-foxes are hunted at night in gardens where they come to eat pawpaw, but more importantly they are harvested from a roost located along the grassland forest margin between Longul and Ogbi. People go there during the day and throw stones, sticks or any handy missile at roosting animals; since there are thousands of flying-foxes over a narrow 1 km stretch, this peculiar hunt is always successful" (Gorecki and Pernetta 1989:88).

"Bats are obtained in daylight by being shot or struck at their roosts in caves or trees, or knocked down in caves or cave entrances with switches or brushes" (Bulmer 1968:311).

"Cave bats were captured by the 'harvest' method. This method has been characterised as appropriate in circumstances with: a) a small target size, b) a clumped target dispersal, c) a specific target location and d) a low risk strategy" (Dwyer and Minnegal 1991:194-195).

The importance of bats, as prey, in New Guinea hunting tradition is borne out through the description of the Moágenda in the Kerám River of the Lower Sepik who began a pay back tribal war with shouts of "[n]ow we will eat the bones of men and the flying-fox; now let us finish up our affair with the Tjimundo" (Thurnwald 1934:349).

These ethnographic descriptions emphasise the cultural importance and difficulties specifically associated with bat hunting. They generally reflect either the driving of the colony into an ambush or the use of powerful and accurate projectiles.

The ethnography indicates that while hunting Chiroptera on the wing (in flight) is achievable, the pursuit of roosting bats has a number of advantages. They roost in large numbers during the day and in the relatively confined space inside a cave and therefore represent a relatively dense resource patch (Binford 1980:5). The enclosed nature of a cave provides the opportunity for the hunter to catch them in a number of ways that increases the likelihood of success. Firstly, the utilisation of projectiles in a cave has greater scope for success than in the open air. A large group of panicking bats in the confined space of a cave with a small number of escape routes makes for an easier target than a colony of Chiroptera dispersing from the forest canopy into the sky. The cave has the effect of a natural trap that holds the prey within range for a relatively longer period of time facilitating the use of additional projectiles. Upon flight from attack, the restricted cave entrance effectively channels the prey through the narrow passage, thereby increasing the predictability of prey behaviour to be exploited to the predator's advantage. The erection of bush material barricades restricts the bats' escape increasing the likelihood of success. The ethnography indicates that hunting bats that roost in caves has much greater potential for higher yields than hunting in the forests.

2.4.9 Rodentia

New Ireland at any one time had five species within the family Rodentia. They are *Rattus exulans*, *R. praetor*, *R sanila*, *R. mordax* and the *Melomys rufescens* (Flannery 1995:418). *Rattus exulans* was introduced into New Ireland with the Lapita expansion 3200 years ago. It is a relatively smaller rodent and is considered to be a human commensal (Spriggs 1997). *Rattus praetor* is also thought to be a human commensal that was first introduced to New Ireland by at least 13,000 bp (White et al. 2000:106). However, the identifications are based on incomplete mandible fragments and await confirmation. In the ethnographic present *R. praetor* is common in productive or recently harvested gardens and according to informants in the bush. "It lives in dry places under stones or fallen trees or amongst tree roots. It has an overwhelming food preference for taro (*Colocasia esculenta*), but also eats sweet potato, papaya, rice, soap, clothing, books etc. Among wild foods it seems to favour *Ficus* sp. and wild pandanus" (Morren 1989:132). White et al. (2000) suggested it was also probably a human commensal. *R. sanila* was initially thought to have been a sub-species of *R. mordax* and has subsequently been raised to species level. It is very similar to *R. mordax* only its molars are more robust, giving them the appearance of being larger. *R. mordax* was present in the basal layers at Matenkupkum and was thought to have gone extinct by 1600 bp (Allen et al. 1989; Flannery 1995:156).

The Highlands *M. rufescens* "...is decidedly a creature of forest gaps, abandoned gardens, vacant settlements, uninhabited houses and grassy areas. It does not climb high in trees and it nests low down in fallen trees, making a fist sized leaf nest. It eats cultigens as well as plant seeds. It shifts seasonally between waterside and secondary growth. In waterside areas it is said to live among the roots of pitpit cane and eat stems of certain waterside plants as well as flotsam, particularly small fruits. In the bush, where it is only rarely encountered, it nests in the stumps of fallen trees and high up in tree holes. Here it feeds on buds, fruit and wild banana shoots, and the epidermis of certain young plants, trees or their branches" (Morren 1989:132). In the Highlands, *M. rufescens* customarily make their nests in dried leaves of *Pandanus conoideus* (Hide et al. 1984:358) and in Mount Elimbari they built sperical nests above the ground (Flannery 1990:232). The Bismarck Archipelago *M. rufescens* is thought to be a subspecies, although it carries the species name at present (Flannery 1995:145).

2.4.10 Reptiles

The mangrove monitor, *Varanus indicus,* is usually found near watercourses or in mangrove and palm swamps, although it is also occasionally found in the rainforest. The common water monitor attains a size of just over a metre and occurs throughout New Guinea where its skin is commonly used for drums (Aplin and Rhoads 1980). *V. indicus* typically belongs in New Ireland's mangrove swamps although is also known to inhabit the rainforests of the interior. Swamp habitat can be found on certain parts of the coastal fringe. Mangrove swamps are a common part of the contemporary landscape. The most extensive of which are located at the northern end of New Ireland, inland of the Balgai Bay (see figure 2). The nearest mangrove swamp to Buang Merabak is 18 km north-west of Buang Merabak at Cape Demogu. The distribution of past mangrove swamps is entirely dependant upon the sea-level. This is because they live within a brackish tidal zone with a low gradient shore line. Contemporary submarine topographical maps were produced with 100 m contour intervals (Marlow et al. 1988) and are not accurate enough to predict the distribution of past mangrove swamps.

2.4.11 Natural History- Summary

The geological, geomorphological and zoological characteristics provide the context for investigations into prehistoric human behaviour in New Ireland. The geology and geomorphology describe the location of the Bismarck Archipelago as off shore islands to continental Sahul. The fauna provide the ecological parameters within which the prehistoric hunter adapted in order to hunt successfully. The descriptions provide the basis for a number of behavioural models that are described following the overview of New Guinea archaeological sites.

3. NEW GUINEA ARCHAEOLOGICAL SITES

This section provides the archaeological context by summarising the major themes of New Guinea faunal analyses and the behavioral models they are interpreted to support. It demonstrates that few sites have been subject to high resolution collection strategies and therefore high quality comparative datasets for the analyses described in the following chapters were rare. Also, few analyses have focused on taphonomic processes placing important interpretative limitations on the data.

Table 3: Selected New Guinea archaeological sites. Calibrated years are expressed as upper case 'BP' and uncalibrated years as lower case 'bp'. It includes additional sites not included in the text to provide additional contextual information.

Site name	Type	Excavator	Basal age	Site location	Site reference
Yuku	Cave	Bulmer, S.	11,760-12,440 bp	NW Mt. Hagen	Bulmer and Bulmer (1964)
Kosipe	Open	White	25,000 bp	Mt. Albert-Edward	White et al. (1970)
Nombe	Cave	White; Mountain	26,000 bp	Chimbu	White (1972); Mountain (1991)
Kafiavana	Cave	White	10,360-11,100 bp	East of Goroka.	White (1972)
Batari	Cave	White	16,150-17,550 bp	Eastern Highlands	White (1972)
Aibura	Cave	White	3800 bp	Eastern Highlands	White (1972)
Wanelek	Open	Bulmer, S.	14,650-15,500 bp	Ramu	Bulmer, S. (1976)
NFX	Cave	Watson.	18,000-21,000 bp	Highlands	Watson and Cole (1977)
Eucla	Cave	Bulmer, S.	12,100 bp	Highlands	Bulmer, S. (1977)
Kuk swamp	Open	Golson	9000 bp	Wahgi	Golson (1977)
Kiowa	Cave	Bulmer, S.	10,350 bp	Highlands	Bulmer, S. (1977)
Kamapuk	Cave	Christensen	4500 bp	Manim Valley	Aplin (1981)
Bobongara	Open	Groube	44,000 bp	Huon Peninsula	Groube et al. (1986)
Lachitu	Cave	Gorecki	35,000 bp (?)	Sepik-Ramu	Gorecki et al. (1991)
Kria	Cave	Pasveer	8000 bp	Bird's Head	Pasveer (2003)
Toé	Cave	Pasveer	25,000 bp	Bird's Head	Pasveer (2003)

A selection of New Guinea sites is listed in table 3 for three purposes. First, to illustrate the range of sites and their antiquity in New Guinea; secondly, to list the sites from which the following description of faunal assemblages and by extension, hunting practices were drawn; and thirdly, to indicate that the majority of the research occurred in the late 1960s and early 1970s. Stone artefacts were the primary objective of a majority of the analyses and the methodologies were designed to suite. Excavations were characterised by the use of 0.25" (ca.5 mm) sieve mesh at Kafiavana, Batari and Aibura (White 1972:3) as was customary at the time. An alternative strategy was to collect a sample of each new layer for analysis. For the Kiowa excavation, at the beginning of each new layer two plastic bags (20 cm x 30 cm) were filled with the largest bones from the deposit (Bulmer, S. 1977:5). Neither of these strategies facilitates collection of smaller bone specimens that are collected with the finer sieve mesh used today.

A variety of analyses and interpretations was undertaken with the New Guinea faunal assemblages. They were the identification of taxa in the site, prey selection, hunting analyses, butchering, bone tool production, faunal material as environmental indicators, faunal extinctions and assemblage preservation and site accumulation, all of which were discussed below.

3.2 Taxa Presence/Absence

The analyses listed the taxa in terms of their respective presence or absence in the assemblage (Aplin 1981; Bulmer, S. 1977; Mountain 1990, 1991; Pasveer 2003; Watson and Cole 1977; White 1972). Kafiavana contained a total of 95 individual animals, of which a majority was the families Macropodidae and Phalangeridae. The assemblage also included Permalidae, Dasyuridae, Megapteroptera, Muridae, Tachyglossidae and *S. scrofa* was present after 4500 bp (White 1972:92). While the Kafiavana basal clay predates human activity it contained representatives of three families including: Macropodidae, Phalangeridae and Muridae. The family Macropodidae was represented by a single broken upper molar, probably M^2 or M^3, thought to be that of a *Protemnodon*. The family Phalangeridae was represented by a mandible of a *Petaurus* (sugar glider), and family Muridae by 20 incisors, and post-cranial elements of both large and small rodents (Plane 1972:168).

Batari contained a total of 186 individual animals, the majority from the families Phalangeridae and Macropodidae. The assemblage also included Permalidae, Dasyuridae, Megapteroptera, Muridae and 15 fragments of *S. scrofa* in Horizons I and II. Birds contributed only 2% of the assemblage and probably include *Gallus gallus* in Horizon II (<3000 bp). Thirteen reptile fragments were also present and unlike Kafiavana, Batari did not contain any Tachyglossidae specimens (White 1972:16-17).

The Aibura assemblage contained 450-500 animals. The cuscus (family *Phalanger*) and the Ringtail possum (genus: *Pseudocheirus*) constituted a large proportion of the faunal assemblage. *S. scrofa* was represented by eleven bones and teeth and one *C. familiaris* premolar was found well above the level of GaK-622 (White 1972:57).

3.3 New Guinea Prey Selection

Prey selection was investigated in terms of species presence and absence over time (Bulmer, S. 1977:1; Mountain 1990; White 1972). Cave bats, birds and forest and grassland animals were hunted by the occupants of Kiowa (Bulmer, S. 1977:4). At Batari reptile bones in the assemblage indicated they were probably a human protein source (White 1972:18).

The Kria and Toé Caves predominately contained evidence of the consumption of *Dorcopsis Muelleri* (Brown Dorcopsis). Interestingly while Phalangerids were extant in the local environment they were present but never dominant in the Bird's Head assemblages (Pasveer 2003:200-203), suggesting they were not the dominant prey taxa.

3.4 New Guinea Hunting

The New Guinea faunal assemblages have been interpreted in terms of human hunting. At Kiowa during the first three phases the cave was used for hunting and collecting while during the final phase it was used for secondary burial (Bulmer, S. 1977:4-5). At Batari the relatively wide range of forest habitat fauna suggested non-specialised hunting practices (White 1972:17). Kafiavana contained a range of wild animals known to inhabit forests and grasslands. Birds, reptiles and fish were brought to the site and eaten (White 1972:108-109). At Batari the high proportion of forest dwelling taxa within the faunal assemblage was interpreted to suggest that most hunting took place in forest environments and perhaps the forest was closer to the cave than today (White 1972:16). The Nombe data substantiated the Hope and Hope (1976) model of Pleistocene use of the forest edge (Mountain 1991:10.4).

3.5 New Guinea Butchering Practices

Butchering was interpreted from the results of the quantities of various elements. At Batari the high quantity of mandibles suggested that most animals were brought to the cave for butchering (White 1972:17). At Aibura the greater than expected number of mandibles to other cranial and post-cranial elements indicated animals were butchered prior to being brought back to the site (White 1972:59).

3.6 New Guinea Bone Tools

The evidence for bone tool manufacture came from the presence of the finished products in the assemblage. At Kafiavana, during Phase I, bone tools were made and may have been stored or discarded at the back of the shelter (White 1972:108-109). Bone tools have also been reported from Toé and Kria Caves (Pasveer 2003).

3.7 New Guinea Environment

Faunal assemblages have been utilised as indicators of local environmental conditions (Aplin 1981; Mountain 1991; Pasveer 2003; White 1972:16-18). At Batari, White (1972:16) notes the relative absence of *Thylogale* in the recent layers that represent a period when grasslands are assumed to be present. At Aibura, White (1972) interpreted the disappearance of *Phalanger* sp. from the upper horizons as an indication of an increase in the grasslands (White 1972:59). The dramatic rise in Rodentia after Horizon IV was interpreted to represent the overkill of larger animals in the area of agricultural expansion (White 1972).

At Nombe relatively high numbers of *T. bruni* were interpreted as indicative of limited forest clearance and *Sus scrofa* with ethnographic correlates with agriculture. The Early-Holocene subsistence economy thus consisted of a mix of shifting agriculture, pig domestication and forest exploitation (Mountain 1991:10.9). Mountain suggested that the presence of almost as many *Thylogale bruni* as *Dorcopsis* sp. and *Sus scrofa* in Stratum B (10,000 bp to 4500 bp) was indicative of the emergence of agriculture.

At the Bird's Head sites of Toé and Kria caves the overall objective of the analyses was the use of archaeological data as a proxy for past environments. The *D. muelleri* mortality profile was interpreted as a reflection of the dynamics of the wild population structure (Pasveer 2003:244-270). This context, reflecting a theoretical perspective that presupposes humans were passive collectors of what was available in the environment, will be returned to later.

3.8 New Guinea Faunal Extinctions

Faunal extinction models have been a common part of archaeological interpretations (Hyndman and Menzies 1980; Menzies 1977; Mountain 1991). At Kiowa a number of taxa were interpreted as extinct by the end of the Pleistocene (Bulmer, S. 1977:1). The assemblage contains the remains of *Aproteles bulmerae*, a species of Chiroptera previously unknown to western science (Hyndman and Menzies 1980; Menzies 1977). The Nombe assemblage contained extinct taxa including *Protemnodon,* Thylacine*, Diprotodon* and *Dendrolagus* species (Mountain 1991).

3.9 Site Accumulation and Preservation

Kafiavana had a relatively small overall number of animals in the deposit that reflects the general destruction of the bone or the dispersal of the bone beyond the limits of the excavation (White 1972:92). At Batari 360 rodent bones in Horizon I were interpreted as representing owl pellets because they formed discrete concentrations of unbroken, un-burnt bones (White 1972:17), suggesting that owls occupied the cave. Humans and owls are highly unlikely to concurrently occupy the same cave. The presence of owls in the cave, at least periodically, suggests that the cave was not permanently occupied by humans. Nombe also exhibited evidence of non-human predators including the Thylacine and possibly Tasmanian Devil- *Sarcophilus harrisii* and *Canis familiaris* (Mountain 1991).

Nombe was the only New Guinea site to contain both artefacts and megafauna remains although it was not possible to determine definitely which if any taxa were human prey. However, Mountain asserts that it was clear that there is a long period of co-existence between the extinct taxa and humans, from about 25,000 bp until 14,000 bp when the megafauna vanished from the site (Mountain 1991).

3.10 New Guinea Archaeological Assemblages- Summary

In the pre-1970's sites the primary objective was the identification of the variety of taxa in the assemblages. The collection strategies targeted the highly diagnostic specimens usually those containing teeth or mandibles/maxillae and those that were large. The interpretations primarily reflect taxa presence/absence, with a few notable exceptions (Mountain 1994; Pasveer 2003; White 1972). The interpretations generally reflect an interest in utilising the fauna as proxies for the environment and tend to regard hunters as passive cullers rather than active hunters.

Analyses of taphonomic processes and the distinction between cultural and natural depositional processes were rare. The association of bones with stone artefacts is a common test of causality and ethnography is utilised as a guide to which taxa are most likely to be natural.

In general, the New Guinea faunal assemblages were dominated by *Phalanger* sp. with the Bird's Head sites as an exception. Macropods were dominant in the Bird's Head sites and the families Reptilia, Rodentia and Chiroptera were also present in all the assemblages.

4. BISMARCK ARCHIPELAGO AND SOLOMON ISLANDS LATE-PLEISTOCENE AND EARLY-HOLOCENE ARCHAEOLOGICAL RECORD

This section is a summary of archaeological research in the Bismarck Archipelago and Solomon Islands and provides the archaeological context within which this dissertation is situated. The sites are described in greater detail than the New Guinea sites because their data and interpretation are central to this dissertation. The discussion includes descriptions of the relevant sites (see table 4), their datasets and interpretations.

Table 4: Bismarck Archipelago and Solomon Islands prehistoric sites.

Site name	**Type**	**Excavator**	**Basal age**	**Site location**	**Reference**
Buang Merabak	Cave	Rosenfeld; Leavesley	32,000 bp	Central New Ireland	Leavesley & Allen (1998)
Misisil Cave	Cave	Specht	11,000 bp	West New Britain	Specht et al. (1981; 1983)
Yombon	Open	Specht; Pavlides	35,000 bp	West New Britain	Pavlides & Gosden (1994)
FABM	Open	Torrence	>27,000 bp	Willaumez Peninsula	Torrence (2001)
Balof 1	Cave	White	7000 bp	Northern New Ireland	White & Downie (1978)
Balof 2	Cave	White	14,200 bp	Northern New Ireland	White et al. (1991)
Matenkupkum	Cave	Gosden	35,500 bp	Southern New Ireland	Gosden & Robertson (1991)
Matenbek	Cave	Allen, J.	20,000 bp	Southern New Ireland	Allen et al. (1989)
Panakiwuk	Cave	Peterson;	15,000 bp	Northern New Ireland	Marshall & Allen (1991)

Pamwak	Cave	Allen, J. Ambrose & Spriggs	21,000 bp	Manus	Fredericksen et al. (1993)
Kilu Cave	Cave	Wickler	28,000 bp	Buka Island	Wickler & Spriggs (1988)

4.2 Misisil Cave

Misisil Cave is located in central West New Britain and contained evidence of human occupation beginning at 11,000 bp. At the time of discovery it was the oldest site in the Bismarck Archipelago and contained evidence of inland occupation. The assemblage included stone artefacts and very small amounts of bone material (Specht et al. 1981; 1983).

4.3 Yombon

Yombon was a series of localities on the ridge tops 500 m above sea level. It is located in dense rainforest some 30 km inland from the south coast of New Britain and was first excavated by Specht in 1966. Recent evidence indicated colonization and inland resource exploitation by 35,000 bp. The early colonists were mobile hunter-gatherers able to move beyond the coastal island fringes of Melanesia and harness important economic and lithic resources located deep within the lowland rainforests. Prior to the Yombon evidence the strandlooper model was widely accepted for the colonization of the Bismarck Archipelago. The strandlooper mode is characterised by sporadic low intensity use of new environments by mobile coastal foragers and is not consistent with the utilisation of inland resources evident at Yombon. Within Yombon's Pleistocene occupation phase there were 27 stone artefacts of locally available fine-grained chert. This small assemblage indicated the use of *in situ* stone material, the production of a particular morphological type (a unifacial ovoid scraper), and microscopic evidence of organic residues and use-wear on several of the retouched artefacts. Evidence of burnt artefacts was interpreted as indicative of activities other than stone procurement although the activities themselves were not stipulated. The Holocene evidence from Yombon was interpreted as representing a number of phases of change particularly at 5500 bp, indicating a change in subsistence strategies. From this evidence it is suggested that the change in subsistence may be from hunting and gathering to agriculture (Pavlides 1999).

4.4 FABM

Torrence (2001) reported preliminary excavations of a low hill that was an open-air Pleistocene site located in the Willaumez Peninsula, West New Britain. It contained obsidian artefacts in stratified tephra deposits dating to at least 27,000 bp (Allen in press). Despite the lack of bone concentrations further excavations will no doubt bear out the importance of this site to the regional prehistory.

4.5 The Balof Shelters

Balof 1 and 2 are described together because they represent two rockshelters that face each other across a collapsed doline. Balof is 3 km inland from Medina village on the northeast coast of New Ireland. They are overhang shelters that face each other across a collapsed doline in secondary forest 80 m above sea level. Even during the height of the Last Glacial Maximum the sites were not significantly further from the coast than today. Balof 1 is 9m by 4m and dates to 7000 bp. It contained an array of faunal material including shellfish, *Phalanger orientalis, Thylogale browni,* Varanidae, Chiroptera and Rodentia (Downie and White 1978; White and Downie 1978).

Balof 2 is 17 m by 14 m and dated to 14,240 bp. Horizon 8 was made up of red clay containing animal bone deposited naturally prior to human occupation. Build-up was slow and sporadic until 10,000 bp and then relatively rapidly until 8400 bp. It contains the same suite of fauna as Balof 1 and was dominated by *P. orientalis* soon after initial occupation. The *P. orientalis* skeletal analysis indicated that individuals were brought to the site whole and the average size of the prey animals did not change over time. The increase in animal remains over time was interpreted as indicating greater sedentism (White 1991:57) facilitated by *P. orientalis* because they re-inhabit relatively more easily known and re-visitable locations (pers. comm., White 12/11/02). *T. browni* was introduced into the diet at 8000 bp and was an important supplement to *P. orientalis*. The Balof faunal assemblage is different to the southern New Ireland assemblages in its composition providing support for the north/south dichotomy in the New Ireland sites (Allen et al. 1989) discussed below.

4.6 Matenkupkum and Matenbek

Matenkupkum and Matenbek are described together because their spatial proximity (they are located in the same cliff-line 70 m apart with no evidence of a past or present barrier between them) suggested to the excavators that they supplemented each other (Allen et al. 1989:557).

Matenkupkum is a large cave being 10 m x 18 m, located at the base of a limestone terrace 15 m above sea-level. Gosden (Gosden and Robertson 1991) excavated a 10 m x 1 m trench from the drip line along the centre of the cave. Artefacts were relatively dense throughout the 1.4 m depth of the deposit. The deposit was divided into three chronological phases. The first unit dates from the Late-Pleistocene, 35,000 bp to 20,000 bp and the second from between 14,000 bp and 10,000 bp with a hiatus in occupation of 6000 years between the two. The final period corresponds with the 1940s.

The assemblage primarily consisted of shell midden material with lesser quantities of bone and stone artefacts. The faunal assemblage was mixed with cultural material with no evidence of non-human predation, suggesting that the bones were the result of human behaviour (Robertson 1986:81). The site represented intermittent occupation by marine-oriented coastal hunters and foragers. It also contained evidence of the use of littoral resources, predominantly shellfish. In the pre-20,000 bp layers the shell assemblage consisted of relatively large individuals of a narrow variety of taxa, while in the 14,000 bp to 10,000 bp unit the average shell size was smaller and the range expanded to include bivalves. This was interpreted from a perspective that has humans as optimal foragers always collecting the largest taxa available and representing the over predation of the larger shells to the extent that they were no longer plentiful after 14,000 bp and therefore alternative smaller shellfish were sought. The faunal assemblage analyses for Matenkupkum and Matenbek are not currently available.

Matenbek is also a large dissolution cave with a main front chamber of 30 m by 20 m and variously up to 6 m high. Entry to the main cavern was by a narrow passage. The original entrance to the cave was blocked in antiquity by a large block of limestone that had fallen from the roof covering the best areas for excavation. Allen (Allen et al. 1989) undertook excavations using artificial light excavating a trench 1.6 m by 0.8 m behind the limestone block. Artefacts in a matrix of midden material were found to a depth of 135 cm, of which the top 45 cm comprised in-washed soil and the remaining 90 cm of intact deposit which was sterile sand. The earliest chronological unit was from 20,000 bp to 19,000 bp and the second from 8000 bp to 6000 bp. The former contained relatively smaller quantities of obsidian compared to the latter, including *P. orientalis* bone specimens and large individuals of *Turbo argystroma*. The latter unit contained large quantities of animal bone and obsidian (Allen et al. 1989:550).

Matenbek and Buang Merabak provide the earliest evidence for the movement of obsidian anywhere in the region. Obsidian from levels dated to 20,000 bp were sourced and found to originate from mostly the Mopir and to a lesser extent the Kutau in west New Britain. Obsidian was found throughout both units of human occupation suggesting continual importation. Matenbek is 350km in a straight line from the Mopir source involving a 30 km sea-crossing of the St Georges Channel. The presence of obsidian over such a long time span suggests multiple repeat journeys (Summerhayes and Allen 1993).

Matenbek, in conjunction with Buang Merabak, also provided the earliest evidence in support of the translocation of animals by humans. *P. orientalis* bones were found at 20,000 bp. As these animals were not endemic they may have been brought into southern New Ireland from New Guinea via New Britain to supplement the diet. This is discussed further in Chapter 8.

Matenbek, Matenkupkum and Buang Merabak contain evidence of the exploitation of sea resources including fish bones in a rich matrix of shell midden material. The fish were shallow water reef-dwellers and the shellfish include large *Turbo argystroma* (Allen et al. 1989). Interestingly, both the Buang Merabak and Matenkupkum assemblages contained large *Turbo* sp. in their earliest units of occupation and have been interpreted as representing the exploitation of pristine shell beds (Gosden and Robertson 1991). Presumably, this suggests that the shell beds in the vicinity of Matenbek were pristine at 20,000 bp, while equivalent shell beds at Buang Merabak and possibly nearby Matenkupkum were not. This situation clearly requires either further investigation of Matenbek or new interpretative frameworks.

Lastly, Matenbek provided early evidence for shell working. From the earliest levels worked *Trochus* sp. and drilled *Turbo* sp. were identified (Smith and Allen 1999). Shell working was also argued for the later Holocene levels as suggested by the presence of sharpened *Trochus* sp. and worked bivalve. Shell beads were also found at 8000 bp along with shell edge ground axe fragments.

An interesting aspect of these sites is that their contents appear remarkably different even though they were in such close proximity to each other (Allen 2000:152; Gosden 1995:811). Matenbek yielded strong evidence of human behaviour during the height of the Last Glacial Maximum while Matenkupkum did not contain any. Matenbek contained 435 fragments of obsidian between 8000 bp to 6000 bp, from a 1m x 1m test pit, while Matenkupkum had a total of 106 fragments from a 10m x 1m trench (Robertson 1986:102). The lack of material might be partially explained as a result of sampling at Matenbek because roof-fall restricted access to some of the deposit. Alternatively, the sites may reflect different periods of residence (Allen 2000:152) leading to the problem of why only one site was used at a time. Additionally, the sites contain evidence in support of the north/south dichotomy. They contained stone artefact and faunal assemblages that were different to Panakiwuk and Balof (Allen et al. 1989:554).

4.7 Panakiwuk

Panakiwuk is located in northern New Ireland 50 km south of Kavieng Town. It is a partially collapsed doline formation 4 km inland from the eastern coastline and Mangai village. The cave has a 20 m high entrance and a floor area of 10 m x 15 m. The first excavation was undertaken in the early 1960s (Peterson and Billings 1965) followed by further excavations undertaken in 1985 as part of the Lapita Homeland Project (Marshall and Allen 1991). The latter included six test pits totalling 5 m^2 and cultural material was found to a depth of 2 m. The stratigraphy was particularly complex, caused partly by a red wedge-shaped deposit interpreted as roof fall. Three major occupation units were identified in the deposit. The first evidence of occupation was from 15,000 bp to 13,000 bp. This was followed by 5000 ^{14}C years of sporadic occupation as small numbers of quartz and chert artefacts reflected a low discard rate. The animal bone included families Rodentia, Reptilia, Chiroptera, Aves and Phalangeridae that were interpreted as suggesting a primarily terrestrial diet. Fish bones were found in the earliest cultural layers, but not in great numbers. Not all the bones were the result of human behaviour as the Rodentia were in part interpreted as representing natural depositional processes or non-human predators. Elsewhere, Rodentia identified in archaeological matrices were interpreted as evidence of owl activity (White 1972). However, some important research by Marshall and others on the identification of owl scats suggests that some of the Rodentia may have been deposited by humans (Dodson and Wexlar 1979; Marshall 1986; Marshall and Allen 1991). Marshall (1986) quantified owl scats collected from captive birds to model the impact of the owl's digestive tract on a rodent's skeleton. Based on comparisons between the owl assemblage and the archaeological assemblage, Marshall and Allen (1991) suggested that the Panakiwuk Rodentia bone were the result of both owl and human consumption.

The second unit, from 10,000 bp to 8000 bp, contains evidence of intensification and a change in human behaviour. Artefacts and midden bone increased according to NISP and were accompanied by marine shell, fish bone, *Crocodylus* sp. and turtle and indicated the exploitation of coastal resources. One piece of obsidian, sourced to the Kutau source near Talasea in West New Britain, a distance of over 600 land kilometres, was also present.

The third unit began after a 5000 ^{14}C year hiatus at 2000 bp and indicated another change in the nature of site. *T. browni* appeared for the first time and the exploitation of local forests expanded to include the presence of *Cocos* sp., *Canarium* sp., *Celtis* sp. and *Pangium* species plants. Four pieces of shell-tempered pottery, one with fingernail-impressed decoration, and 9 fragments of obsidian, seven from Lou Island, and two to Kutau in west New Britain, were present. The pottery and obsidian data fit into the Late-Lapita phase with comparable deposits dating to between 2000 bp to 1600 bp (Marshall and Allen 1991).

The red wedge feature in the Panakiwuk stratigraphy complicated the site's interpretation. In addition the faunal assemblage was unique within the New Ireland context because it primarily contained Rodentia. Therefore, interpretation of the site was necessarily cautious.

4.8 Pamwak

The Pamwak Rockshelter is 4 km inland, 30 m above sea level and located 100 m west of the Losa (Chobur) River of southeastern Manus Is. in the Admiralty Group (Fredericksen 1994:55). Manus is approximately equidistant (230 km) from both New Guinea and New Ireland. The colonization of Manus represented a water crossing 60-90 km beyond the sight of land (Fredericksen et al. 1993:151; Irwin 1992) and was the first sea crossing of this distance in the region. Pamwak was first occupied prior to 21,000 bp (Fredericksen et al. 1993:149; Minol 2001:25). Pamwak was interpreted as a base camp for a relatively large group of people. After 10,000 bp the site contained formal tools including edge ground axes, reminiscent of Australian

Sahul rather than the Huon Peninsula, knives and scrapers. The lack of manufacturing debris at the site suggested they were manufactured elsewhere (Spriggs 1997:59).

The geo-chemical characterisation data and stratigraphic association of the Pamwak obsidian indicate that it originated from Pam Is. during the terminal Pleistocene. Artefact analyses indicate that Pamwak had increasing accessibility to the source through time and incorporated increasing quantities of Lou Is. obsidian particularly in the period contemporaneous with Lapita (Fredericksen 1994; Fredericksen et al. 1993).

The shell analysis indicated a close relationship between shellfish taxa and sea level. When sea level was high the midden contained a greater variety and quantity of marine taxa and inversely when sea level was lower the midden contained a higher proportion of mangrove and estuarine taxa (Schmidt 1996).

The pre-12,000 bp levels at Pamwak contained a relatively low density of bone specimens probably as a result of various taphonomic processes. Of the preserved material, family Varanidae lizards and small quantities of Chiroptera and Murids were the dominant taxa. *Echymipera kalubu* appeared at 12,000 bp and *Spilocuscus kraemeri* occurred soon after at 11,500 bp. *E. kalubu* was widespread in New Guinea and New Britain and was introduced from the former (White in press). They were important because they, particularly *E. kalubu,* subsequently become the major focus of the Pamwak diet (Williams 1997).

4.9 Regional Late-Pleistocene and Early-Holocene Archaeological Record - Summary

The sites described above provide the data that is the basis for the models of human behaviour during the Pleistocene in the Bismarck Archipelago and Solomon Islands that are described below. What follows is a description of the models themselves.

5. MODELS OF BEHAVIOUR

The models described below are a reflection of colonization, subsistence strategies, transportation of materials and animals, mobility and hunting strategies. They are preceded by two models from the culture history perspective that reflect artefact distributions on first a regional scale and secondly a New Ireland scale. The first reflects artefact distributions across the Bismarck Archipelago and Solomon Islands and the second concentrates specifically on New Ireland. While this approach is somewhat dated it provides a useful framework within which to order the data from disparate sites prior to discussions of human behaviour within the other theoretical frameworks described below.

5.2 'Pulses of Activity'

Leavesley and Allen (1998) identified six pulses of activity reflected in the Bismarck Archipelago and Solomon Islands datasets. They reflect site chronologies, density of deposition, contemporaneous occupation and the appearance of specific objects in the assemblages. The pulses were:

- >35,500 bp - reflects a low-intensity initial incursion in the Bismarck Archipelago.
- 20,000 bp - exotic introductions including obsidian that occurred in the sites.
- 14,000 bp - re-use or initial use of sites in widely separated areas.
- 10,000 bp - sites exhibit their most intensive deposition rates.
- Mid-Holocene - most sites were unoccupied/irregularly occupied.
- 3300 bp - Lapita appeared in the region.

The first pulse occurred with the colonization of the region. Leavesley and Allen (1998) followed Pavlides and Gosden (1994) for the first evidence of colonization but subsequent research undertaken as part of this dissertation and indicated that the region was colonised slightly earlier. (Leavesley et al. 2002). The increase in antiquity of colonization by 4600 ^{14}C years from 35,000 bp to 39,590 bp was not considered large enough to change the overall nature of the model. The remaining five pulses remain as they were originally described (Leavesley and Allen 1998). A limitation of the model was that it reflected the entire region as a homogenous unit and does not facilitate inevitable island specific diversity. For New Ireland, this limitation is exemplified by the Allen et al. (1989) north/south dichotomy.

5.3 North/South Dichotomy

Allen et al. (1989) suggested that the overall character of the New Ireland cave site assemblages indicated a significant difference between behaviour in northern and southern New Ireland based on two criteria:

- first, the southern sites of Matenkupkum and Matenbek were occupied prior to the Last Glacial Maximum while the northern sites of Panakiwuk and Balof were occupied after;
- second, the southern faunal assemblages were dominated by bats, rats and cuscus while the northern faunal assemblages were dominated by bats, rats, cuscus and Pademelon.

The model points to a number of interesting trends in artefact discard. However, it does not provide an explanatory framework. Notions of north and south presuppose the primacy of topography and place Buang Merabak, located in central New Ireland, in an important location to investigate the spatial extent of various artifact classes.

The models that follow engage with human behaviour based on the distribution of artefacts. They reflect aspects of colonization and the subsequent adaptation to island environments in general and New Ireland in particular, in terms of resource use and mobility.

5.4 Colonization Models

The colonization of the Bismarck Archipelago and Solomon Islands are directly related to that of New Guinea and Sahul. The earliest estimations of New Guinea occupation are listed in tables 2 and 3 and those for northern Australia in table 5.

Table 5: Selected Northern Sahul colonization sites in Australia.

Site	**Location**	**Basal Age**	**Technique**	**Reference**
Nauwalabila	Arnhem Land	57,000 bp.	OSL	Roberts et al. 1990
Malakunanja	Arnhem Land	55,000 bp.	TL	Roberts et al. 1994
Ngarrabullgan	Cape York	38,000 bp.	^{14}C, OSL	David et al. 1997

The data in table 5 have been discussed in detail elsewhere (Allen 1989; Chappell 2000; Gillespie 2002) and are not reiterated here suffice to say that settlement of Sahul occurred in the order of 50,000 bp (Allen and O'Connell 2003:17) and perhaps slightly earlier. New Guinea appeared to have been colonised slightly after Australia and Birdsell (1977) proposed two possible routes. The routes themselves were based on estimates of the shortest sea crossing and while they were parsimonious they were not supported by any specific archaeological evidence. The northern route passed through Borneo and Sulawesi and into northern New Guinea via the Bird's Head. The southern route passed through Sumatra, Java and Timor into northern Australia. Birdsell (1977) did not necessarily distinguish between either of the two routes. However, recent research has focused on distinguishing which of the routes was more likely. Chappell (2000) suggested the colonists of Sahul followed the Timor route directly to northern Australia and later into New Guinea. This contradicts the suggestion that colonists followed a coastal route to the Huon Peninsula that was the nearest stepping-off point to west New Britain and into the Bismarck Archipelago. It also implied that the colonists of the Bismarck Archipelago would have had to re-learn the maritime skills required to cross the Vitiaz Strait rather than inheriting them from a long line of mariners (Chappell 2000). Alternatively, Allen (in press) has suggested that, based on Irwin's (1992:28) observations on the difficulty of a two way sea crossing between Australia and Timor, entry into Australia via the Bird's Head was more likely.

The earliest evidence of the colonization of New Guinea is 44,000 bp. It was derived from the Huon Peninsula (Chappell 2000; Groube et al. 1986) and possibly Lachitu (Gorecki 1991), but the latter is yet to be substantiated. The Huon Peninsula material was dated by association with its sediment matrix rather than the artefacts themselves and has been identified as a limitation to the reliability of the results (Allen 1989; Allen and O'Connell 2003). Therefore the only undisputed evidence comes from Yombon, Matenkupkum and Buang Merabak.

5.4.2 Bismarck Archipelago Colonization

The Bismarck Archipelago was the first true Pacific island archipelago to be colonised beyond Sahul. The archaeological signature consisted almost exclusively of simple flake and core tools. They were made of locally available rocks, primarily fine-grained igneous or metamorphic types. There was no evidence before 20,000 bp of the transport of raw materials over long distances (Leavesley and Allen 1998), although clearly material was brought shorter distances from the local streams to the cave sites. Although the source location of the fine-grained cherts was unknown, it was highly likely that the latter occurred in association with the New Ireland limestone as chert resources have been identified in nearby New Hanover (Leavesley 2000).

Models of the colonization of Near Oceania commonly began by describing the similarities between the region from which the colonists came (Allen 2000), and the region that was colonised (Spriggs 1997:28). Variation between regions was evaluated to determine the possible barriers and conversely the similarities that were interpreted as corridors to colonization. As sea-levels were generally 40-70m below present levels for most of the Pleistocene, water gaps between many of the high islands were similar to today. Inter Island visibility was a feature of successive bodies of water from the edge of Sundaland all the way to the Bismarck Archipelago including Mussau, which was visible from the foothills of the Tirpitz Range in New Hanover during fieldwork in the year 2000. Inter-regional comparisons indicate that once humans reached Sahul they had acquired the necessary technical and maritime skills to make the journey from New Guinea to New Britain.

The nature of food resources reflected by the fauna might also represent a barrier to colonization. In 1988 (Allen et al.), the first evidence of pre-30,000 bp human occupation of the Bismarck Archipelago emerged requiring a re-consideration of the associated issues of how and why it came about. Allen (2000:144) following Bowdler (1977) suggested that the marine resources in the Bismarck Archipelago were relatively similar to those already encountered by humans further west and therefore when humans moved into the Bismarck Archipelago the coastal fauna was a familiar one. While this was generally true it may not be specifically the case. A recent analysis of a series of Indonesian reef taxa suggested that they may not be as mobile as first thought (Barber et al. 2000). While the evidence does not specifically contradict the Allen (2000) model, it does suggest the possibility of subtle differences between reef systems and thus possibly reef faunas.

5.4.3 Bismarck Archipelago Colonization: Deliberate or Accidental?

The sea crossing from New Guinea into the Bismarck Archipelago was surely the result of more than mere haphazard mistakes, although whether they were deliberate voyages of exploration or the result of misadventure was hard to prove (Mountain 1990:55). Allen and Gosden (1996) suggest a method to distinguish whether the colonization of the Bismarck Archipelago was deliberate or accidental. If colonization occurs immediately after the settlement of the nearest point of departure from New Guinea, then the settlement of the Bismarck Archipelago might be considered part of a deliberate strategy of colonization. Alternatively, if there was a time lag between the colonization of New Guinea and the Bismarck Archipelago, then it might be considered an indication of a non-deliberate strategy of colonization.

The shortest sea-crossing from New Guinea/Sahul to the islands of the Bismarck Archipelago is the Vitiaz Strait. In order to consider the Allen and Gosden (1996) proposition, the evidence of occupation from either side of the Vitiaz Strait was instructive. The earliest evidence of human occupation in the Bismarck Archipelago is 39,590 bp (Leavesley et al. 2002). More contentious is the important research by Groube et al. (1986) and their refinement of the Huon Peninsula chronology. Groube et al. (1986) initially suggested a 55,000 bp (TL) age for human occupation that was subsequently refined to 40,000 bp (Chappell 2000) and has two limitations. First, without adequate calibration of ^{14}C into calender years it was difficult to determine precisely the difference between the determinations from the two techniques. Secondly, the Huon Peninsula data must be considered in the light of Allen's (1989) interpretation that it was difficult to demonstrate a direct connection between the sediments dated by TL and the archaeological remains. However, accepting the limitations of the Huon Peninsula data, the Buang Merabak results demonstrate the time of arrival in the Bismarck Archipelago irrespective of the time of departure from New Guinea.

Spriggs (1997) describes the colonization of Manus as the result of exploration because the sea gap to reach Manus represented a real threshold in voyaging ability, as Manus was beyond the range of one-way inter-visibility. Previous sea-crossing from Sunda to Sahul covered distances that were short enough for the colonists to be able to see their destination island prior to departure. Manus was not visible from New Guinea, therefore requiring the colonists to travel a considerable distance off-shore before they could see their ultimate destination. In this context, exploration reflected a context within which the explorer searched to find somewhere to explore, rather than exploring an island that was already known. Expansion was a process of incremental movement into an area that could be seen from a previously known location. For example, the colonization of an off shore island that could be seen by the population prior to launching canoes was considered as expansion while an island over the horizon and therefore requiring a preliminary journey to discover its' existence prior to populations launching their canoes was considered representative of exploration. The Manus colonists were involved in a blind crossing of 40-60 km before sighting land. The colonization of the Bismarck Archipelago (presumably via east New Britain and New Ireland to Mussau) need not represent exploration and favored expansion as the result of a series of incremental increases in the known territory of a group of individuals.

5.5 Bismarck Archipelago and New Ireland Adaptation Models

Irrespective of the timing or various mechanisms, all agree that the colonists were most likely small groups of people. This was indicated by the small number of sites dating to the period immediately post-colonization and the relatively small amount of artefacts and midden material compared with larger groups of people moving into the Bismarck Archipelago (Allen and Gosden 1996:187; Allen et al. 1989).

Spriggs (1997:30) suggested that it was scarcely conceivable that colonization episodes were one-off events. In order to establish a viable population a broad gene pool was required. Further contacts after initial settlement cannot be demonstrated unless resources that have been sourced to another island were found in archaeological deposits (Spriggs 1997:30). Alternatively, post colonization contact might be inferred if the newly colonised region contained a vast array and quantity of cultural sites and debris that could not have reasonably been produced and deposited by a single colonising group of people.

Gosden suggested that the lack of land resources could have been balanced by the richness of those of the sea (Enright and Gosden 1992:173; Gosden 1995; Spriggs 1997:39). Allen (2000) suggested that the colonists had a coastally oriented strategy. However, it was clear that our knowledge of this critical formative period of settlement of island Melanesia was limited by the lack of sites from this period (Spriggs 1997:39). The following models pertain specifically to the Bismarck Archipelago and Solomon Islands and reflect notions of resource use, land use and mobility.

5.5.2 Arboriculture

Human populations required a balanced diet including both protein and carbohydrate. While carbohydrate could be extracted from mammal bone marrow it was more easily extracted from vegetation. The New Ireland cave sites contained large quantities of shell and bone and lesser quantities of plant material. The bones represented taxa mostly less than 3-4kg in size that was considered too small to contain sufficient amount of marrow in their medullary cavities to support human populations. As agriculture did not appear in New Ireland until after the Mid-Holocene, carbohydrate must have been procured by an alternative means. One such alternative was orchard-based tree cropping known as arboriculture (Kirch 2000:82). An array of botanical remains was collected from Pleistocene deposits and identified to taxa. These included *Canarium indicum, Cocos* sp., *Aleurites, Terminalia, Panadanus, Pangium, Spondias* and *Dracontomelon* (Spriggs 1997:79) and *Celtis* sp. (Leavesley and Allen 1998). Residue observed on the Kilo stone artefacts indicated the utilization of both *Alocasia* and *Colocasia* Taro in Buka (Loy et al. 1992). Although taro did not explicitly suggest arboriculture, it does support assertions pertaining to the utilisation of plant foods. Plant residue in the form of starch grains was also identified on the Balof stone artefacts including *Cyrtosperma merkusii, Alocasia macrorrhiza* and *Xanthosoma sagitifolia* (Barton and White 1994:175). Gosden (1995) has suggested that cumulatively the evidence supported a strong case for arboriculture.

5.5.3 Resource Use

Allen et al. (1989) suggested that for the first few thousand years of habitation the sea was an important conduit for human mobility. It facilitated movement between scarce resources as well as being an important source of protein (Spriggs 1997:39). Gosden and Robertson (1991) proposed that prior to 20,000 bp people moved around the Bismarck Archipelago in order to exploit dispersed resources and after 20,000 bp some of the resources were moved to the people. The model was based on the lack of obsidian and *P. orientalis* in the pre-20,000 bp deposits at Matenkupkum and their presence in the post-20,000 bp Matenkupkum and Matenbek (Gosden 1993:133). The results indicate two important aspects of the assemblage. First, the pre-20,000 bp period assemblage was relatively low in terrestrial fauna remains (an issue to be returned to in chapters 6 and 8) and secondly, the presence of New Britain obsidian and the *P. orientalis* in the New Ireland assemblage marked an important change in prehistoric behaviour. However, although New Ireland was significantly faunally depauperate, it did contain a variety of potential food plants (Gosden 1995). The lack of obsidian in New Ireland prior to 20,000 bp suggested that either the resource was not available at its source or that those who occupied New Ireland did not move within the social networks that had access to the source area.

5.5.4 Animal Translocation

The idea of the human translocation of animals between islands is not new (e.g. Wallace 1869). *P. orientalis* first appeared in New Ireland between 19,000 bp and 20,000 bp and was thought to be the product of accidental (or less likely deliberate) human behaviour (Flannery and White 1991; White 1993:174). Flannery and White (1991) list five criteria on which they base the human translocation interpretation. First, it was moved extensively elsewhere in Melanesia and the world (Grayson 2001). Secondly, its habit of commonly producing twins makes establishment on previously uninhabited islands more likely. Thirdly it can inhabit a range of environments, being a lowland species with broad ecological tolerance, able to survive in primary and secondary forest as it has a generalist diet (Flannery 1993:175). Fourthly, the natural translocation of *P. orientalis* appeared unlikely because it did not occur in New Ireland for over 1 million years prior to humans (Flannery and White 1991:108). Flannery (1993:175) subsequently added that the New Ireland *P. orientalis* colonisers were probably 'back young' or young animals that developed beyond dependence upon their mothers milk but remained with their mother, on her back. 'Back young' were considered to be the optimum age because younger animals could have easily succumbed to illness and older animals were less tractable and more likely to be injured during capture or suffer from 'capture myopia'. And fifthly, there was an extensive ethnographic literature of animals kept captive and transported between islands (Heinsohn 1998, 2001; Swadling 1996; White in press). However, Specht (in press) questioned animal translocation in two areas. First, land-based animal protein was limited particularly during the Pleistocene (Allen 2000:144-145). If human translocation of animals was a strategy to increase the availability of island-based prey, it was not very successful. And secondly, the appearance of taxa in an archaeological deposit represented its first introduction into the human diet rather than into the natural environment. A natural deposit of bones, such as a sink-hole, would be an ideal context in which to determine when a taxon first entered New Ireland (Heinsohn 1998:77; Specht in press). In the absence of any systematic palaeontological studies in New Ireland, there was not any pre- 20,000 bp natural material with which to compare the archaeological assemblages. In addition, "recent natural range extensions and human-assisted dispersals may mimic each other in effect and that zoogeographic evidence may be inconclusive" (Heinsohn 1998:76). Although the case for the human translocation was strong there were a number of lines of scientific enquiry yet to be pursued, that could provide a better understanding of the processes that brought *P. orientalis* to New Ireland. Nevertheless, the human translocation of important prey taxa potentially reflects behavioural complexity through an intimate knowledge of New Ireland's fauna. It also reflects the introduction of a population large enough to be genetically viable.

Irrespective of how the *P. orientalis* reached New Ireland, its appearance coincided with, but may or may not be related to, the introduction of the aforementioned change in shellfish selection at Matenkupkum. The *P. orientalis* may have taken the pressure off the pre-existing prey taxa, in this case moving the emphasis of protein procurement from the rocky shore (for shellfish) to the adjacent forests (for the *P. orientalis*). If these two events were linked, it may reflect a human response to changing availability of prey and an important adaptation to the environment.

A second species identified as a human translocation was the *Thylogale browni* which first appeared in the New Ireland archaeological sites at 8000 bp (Allen et al. 1989). Flannery and White (1995) suggested that *T. browni* may have arrived on New Ireland as a result of human translocation in the absence of any other obvious mechanism and on the grounds that Macropods, as a rule, were not strong swimmers. However, Wex (1999) reported a young wallaby found swimming 7 km off the coast of Cairns. While this evidence does not demonstrate the natural dispersal of Macropods and in particular the *T. browni* across the Bismarck Archipelago, it does suggest the possibility that the swimming capabilities of Macropodidae have not yet been fully explored.

5.5.5 Over-Predation Model

The first colonists undoubtedly had to adjust their behaviour in order to survive in an environment with a different range of taxa to their place of origin. The product of hunting and gathering may have become skewed, if not specialised towards the taxa known previously from New Britain, although there was very little evidence as to what it might have been. A case in point was the shell midden at Matenkupkum. After the initial colonization of New Ireland, people selected the larger individual specimens from a narrow range of the larger available taxa. The collection pattern subsequently alters to smaller sized specimens from a wider range of taxa. This model has a number of implications. First, it suggested selective shellfish gathering requiring knowledge of the range of taxa availability and a predetermined decision about which taxa were most desirable. Secondly, Robertson (1986:116-120) suggested the case for 'over-predation' could be strengthened in three ways. First, the actual sample for the earliest time unit could be increased to represent a larger sample of human behaviour. Although the excavation trench was 9 x 1 m, the earliest time unit contained a relatively low quantity of specimens (Robertson 1986:66-67). Secondly, the site chronology could be investigated further with the aim of shortening the temporal units. Presently the chronological units span 10,000, 6000 and 2000 ^{14}C years respectively. In the best case scenario the requisite temporal units might reflect the life cycle of the respective taxa. Increased chronological control might be achieved by re-dating the site with the objective of refining and narrowing of the temporal units. Thirdly, more malacological research on the requisite taxa in the region would facilitate a more informed consideration of the environmental effects of the human collection on shellfish populations (Spriggs 1993:190).

5.5.6 Shellfish as a Reflection of Environmental Change

An alternative explanation for the change in taxa might be a change in environmental conditions rather than over-predation (Spriggs 1993:190; Swadling 1994). Different taxa thrive in different ecological zones. The taxa changed over time because the sea level changed in line with the Last Glacial Maximum and therefore the coastal habitats changed as well. The changing sea level drives the changing habitats that facilitate different taxa. The human shellfish collector selects the most abundant taxa at any given time.

This interpretation might be strengthened by further research into the nature of long-term sea level change and its impact on shellfish habitats. An alternative perspective might be the investigation of the nature of natural Pleistocene shell accumulations with a finer scale resolution.

5.6 Lapita in Circum-New Ireland

While the Late-Holocene was not initially the primary aim of this dissertation, the implications for Lapita were very important to an understanding of the relationship between Lapita and pre-Lapita populations. This section provides a brief outline of the Lapita Cultural Complex that was considered as a contemporary to behaviour reflected at Buang Merabak and described and compared in chapter 7.

Lapita is archaeologically identified by red-slipped pottery including distinctive dentate, incised or applied motifs. Lapita pottery is the archaeological manifestation of the Austronesian expansion into Remote Oceania. The Lapita Cultural Complex was characterised by a sedentary village-based community structure based on swidden agriculture and including animal husbandry of *Sus scrofa*, *Gallus gallus* and the animal companion *Canis familiaris* and commensal *Rattus exulans*. Lapita was variously defined into phases based on the motifs. Dentate motifs occur in the Bismarck Archipelago at 3200 bp, continuing until 2700 bp, when they are replaced by incised and later applied motifs (Spriggs 1997; Summerhayes 2000). Non-Austronesian languages are older than Austronesian languages and exist on all the islands that have evidence of human occupation prior to Lapita. Subsequent to the arrival of Lapita on New Ireland, agriculture became the dominant form of subsistence and Austronesian the dominant language, although one Papuan language remains (Lindstrom 2002). Non-Austronesian is considered to be a remnant of hunter/gatherer populations and Austronesian is associated with agriculture (Specht in press). Lapita sites commonly reflect occupation for only a few hundred years and have been interpreted reflecting a degree of mobility of entire villages over equivalent time spans (Summerhayes 2000) and fall within the scope of mobile agriculturalists described by Gorecki (1991:239). The Lapita chronology for Circum-New Ireland is relatively well known. Classic (dentate) Lapita sites occur on the smaller off shore islands at the Duke of Yorks (Specht 1969), Mussau (Kirch 1997) and Kamgot (Summerhayes 2000) at 3500 bp. The first Lapita sites occurred on New Ireland at 2700 bp at Lamau (Gorecki 1991), Lesu (White and Downie 1980), Fissoa (White and Murray-Wallace 1996), Pinikindu (Clay 1974) and most importantly at a nearby village to Buang Merabak called Lasigi (Golson 1991). Lasigi was a village ca. 5 km from Buang Merabak and contained two Late-Lapita sites. The pottery had incised and applied motifs and the faunal assemblage contained *S. scrofa* bone specimens

(Golson 1991:251). The Late-Lapita sites indicate the first movement of Lapita people from the off shore islands to New Ireland itself.

The temporal overlap between the Buang Merabak assemblage representing hunter-gatherer populations and the Lasigi assemblage representing sedentary agricultural populations allows for a rare opportunity to investigate the impact of the movement of Austronesians onto New Ireland. This allows for an investigation into concepts of semi-sedentism and mobile agriculturalists such as described elsewhere by Goodale (1996[1926]) for the Kaulong in West New Britain.

6. CONCLUSION

This chapter has described the research that has occurred in the Bismarck Archipelago and Solomon Islands describing both the individual sites and the synthetic models. It has provided the background geological, geomorphological environmental data that characterise those models and provide the environmental parameters that underpin the model proposed in chapter 8 of this dissertation. The chapter has identified the general lack of faunal assemblage analyses in New Guinea and has suggested that faunal data can make an important contribution to our understanding of colonization, resource use, hunting, land use and mobility in New Ireland and the Bismarck Archipelago.

Chapter 3

Buang Merabak: Previous Research, Stratigraphy, Chronology, Units of Analysis and Site History

1. INTRODUCTION

This chapter describes the background archaeological method and interpretations for Buang Merabak as contextual data in the construction of units for this analysis. It describes the first excavation carried out by Rosenfeld (1985) and subsequently analyzed by Balean (1989) and Leavesley (1996) culminating in two site syntheses (Leavesley and Allen 1998; Rosenfeld 1997). This is followed by a description of the 2000 re-excavation describing the stratigraphy and chronology culminating with a site history and the presentation of the units utilized in the following chapters.

2. THE BUANG MERABAK CAVE SITE

The archaeological potential of the region was first described in the mid-1970s (Clay 1974). In 1984 and as part of the Lapita Homeland Project, Buang Merabak was selected for archaeological investigation (Allen *et al.* 1985:13). Buang Merabak is located adjacent to the coastal village of Konogusngus in central New Ireland, Papua New Guinea. The Buang Merabak is a cave in the base of a series of limestone terraces that rise ca. 1000 m to the Lelet Plateau. The mouth of Buang Merabak is 150 m above the present sea level and 200 m from the coast.

Cave morphology has implications for site formation. The Buang Merabak cave consists of three chambers connected by short passages. The main entrance to the first chamber faces NNE and is 15 m wide and 8 m high. In 2000, a calcite column, with a 1 m diameter, was situated in the middle of the chamber (illustrated as a stalagmite in Rosenfeld 1997:214-215). The first chamber also contains two 'dry stone walls', the first of which is located at the mouth of the cave and consists of a series of (6-8) large boulders. The second wall is located 25 m inside the cave. It is in front of the low roof that opens into the second chamber (see Rosenfeld 1997: figs. 1 and 2). Between the first stone wall and column the cave floor consists of loose sediment. The floor around the base of the column is stone bedrock or possibly thick flow stone. Between the column and the second stone wall is another relatively flat area of sediment contains remnant posts and post-holes said to be the remnants of structures built and utilized during WWII. A small colony of Micropteroptera inhabited the back of the first chamber during visits to the site in 2000, 2001 and 2002.

The second chamber is a collapsed doline. Very little of the original stone ceiling remains allowing plenty of light to enter from above. The chamber is broadly circular (10 m diameter by 15-20 m high) with a boulder floor that slopes a quarter of the way up the west wall. The western half of the boulder floor area was covered with rotting trees that fell in through the top of the doline. Black hand-stencils (Brown et al. 1976:127; Wilde 1975:6-12) were present on a relatively dry area of the eastern wall. The chamber also contained remnant rain-making apparatus belonging to the late Ephraim Telexas. The apparatus consisted of four giant *Tridacna* sp. shells strategically placed to catch drips of water from the collapsed roof. The *Tridacna* sp. shells contained human bones, predominantly long bone and cranial elements.

From the southern end of the second chamber a short (10-15 m), low-roofed (<1 m), narrow rocky passage leads to the third chamber. The passage was not large enough to host anything but the smallest of animals. The third chamber is 50 m x 30 m and contains two levels joined by a boulder slope. The passage from the second chamber opens into the lower level. The upper level of the third chamber had a hole in the roof commonly used by the resident Chiroptera colonies. A Megapteroptera colony was said to live here although less than twelve were present in October 2001. The northern end of the floor of the upper level was covered with boulders while the southern end was covered by a layer of guano and evidence of modern bat hunting activities (ca. 50 large sticks/small branches of between 30 cm and 90 cm in length and ca. 5 cm diameter). Within the southern end of the upper level, a third passage spiralled down 10-15 m to its terminus. During 2001, the third passage was occupied by a small colony of Micropteroptera (including *Hipposideros* sp.).

2.2 The 1985 Research

The 1985 excavation was the forerunner of this research project. It highlighted important aspects of the site including both potential for future research as well as site formation and taphonomy. In order to appreciate the direction and methods of this research it is important to appreciate the data collection methods and analyses employed. In particular, the excavation methodology, stratigraphy, chronology and the nature of the assemblage analyses are described.

2.2.2 The 1985 Excavation

In 1985, three 1 x 1 m squares (SQ 2A, 2B and 2F) were selected for excavation (Balean 1989:6). Squares 2A and 2B were located behind the first stone wall and drip-line inside the mouth of the first chamber. Of the two squares, only 2B was excavated to bedrock at 165 cm below the present cave floor. The relatively homogenous nature of the sediment necessitated the use of arbitrary 5cm spits. The excavation proceeded in 50 x 50 cm quadrants and arbitrary 5 cm spits measured with a dumpy level. Bulk samples were collected but lost in transit from Port Moresby to Canberra. The deposit was weighed in buckets, with a spring balance, dry sieved through 5 mm mesh. The stone residue collected from on top of the sieve was weighed prior to being discarded.

2.2.3 The 1985 Excavation Stratigraphy

The 1985 excavation results suggested that the Buang Merabak stratigraphy was relatively homogenous in colour and texture. Six stratigraphic units were identified by Balean (1989) and Rosenfeld (1997): “a first order framework of the Buang Merabak stratigraphy could be drawn from the 1985 excavation. The upper 10-15 cm was ‘unconsolidated, loose and dusty’. Below this the deposit throughout consisted of clay and limestone breccia, although ‘between 40 and 55 cm the deposit was more silty’ with ‘fewer large stones’. Between 60 and 90 cm, ‘post-depositional calcrete had cemented the deposit and its cultural material into irregular lumps.’ From 90 cm to the base, “many limestone fragments were corroded to small pieces of friable orange rock” (Leavesley and Allen 1998:65).

2.2.4 The 1985 Excavation Chronology

Ten ^{14}C determinations, listed in table 6, represent the site chronology based on samples collected in the 1985 excavation. In this dissertation ‘bp’ refers to an uncalibrated age and ‘BP’ refers to a calibrated age. The first three determinations (ANU-6612, ANU-6613 and ANU-6614) were reported and utilized by Balean (1989:7) and the remaining 7 were reported and utilized by Leavesley (1996:52) and Rosenfeld (1997:217). Three of the determinations (ANU-7506, ANU 6961 and ANU-6612) were considered anomalous and therefore cast doubt over the entire sequence (Rosenfeld 1997:215-216). Determination ANU-7506 was the only charcoal determination, raising the question of whether the chronological differences in the sequence reflect unknown chemical alteration within a specific material used for dating. Determination ANU-6961 may represent post-depositional disturbance rather than a technical dating problem. It was in spit 4, only 1 spit below two 4000 bp determinations (ANU-6965 and ANU-7505). While ANU-6961 was not contemporaneous with either ANU-6965 or ANU-7505 it may have moved as little as a few centimetres or as much as 10 cm and therefore may be interpreted as indicative of post depositional disturbance (Leavesley and Allen 1998).

Table 6: Buang Merabak SQ2B ^{14}C determinations from Balean (1989), Leavesley (1996) and Rosenfeld (1997).

Square	**Spit**	**Material**	**Lab. Code**	**Age (bp)**	**Rosenfeld comments**
SQ2B	3	Shell	ANU-6959	4270±60	
SQ2A	3	Shell	ANU-7505	4040±60	Check for ANU-6959
SQ2A	3	Charcoal	ANU-7506	440±90	Check for ANU-6959: anomalous?
SQ2B	4	Shell	ANU-6612	2490±80	Anomalous?
SQ2B	7	Shell	ANU-6960	5810±110	
SQ2B	10	Shell	ANU-6613	10,800±110	
SQ2B	16	Shell	ANU-6961	2340±70	
SQ2B	16	Shell	ANU-7507	20,890±270	Check for ANU-6961
SQ2B	25	Shell	ANU-6962	20,350±290	
SQ2B	30	Shell	ANU-6614	31,990±830	

Of the remaining 7 determinations, the oldest, and stratigraphically lowest, returned a 32, 000 bp estimate (Balean 1989:7). It was overlain by two 20,000 bp determinations that were 9 spits (45 cm) apart (and overlap at 1σ), raising the possibility of either disturbance or a period of increased sedimentation. The latter was considered more likely by Leavesley (1996; Leavesley and Allen 1998). Rosenfeld (1997:217) interpreted ANU-6961 as anomalous. The next youngest determination is ca. 11,000 bp followed by another group at ca. 4000 bp.

2.2.5 The 1985 Assemblage Analyses

Two sets of analyses were reported for different aspects of the assemblage. An analysis of the shell assemblage from Square 2B (SQ2B), SE quadrant was undertaken by Balean (1989). The lower layers contained a small range of taxa represented by relatively large individual shells. The upper layers changed over time to a wider range of taxa represented by small individual shells (Balean 1989). The basic pattern was comparable to Matenkupkum (Robertson 1986) and interpreted similarly as evidence of prehistoric over-predation of shellfish resources.

Additionally, the assemblage was compared to ethnographic evidence and interpreted as representing the use of the cave as a refuge during times of social pressure such as war (Balean 1989).

Balean (1989:3) also noted the presence of pottery in the sequence. Pottery appears in New Ireland in conjunction with Lapita at 3300 bp (Anderson et al. 2001; Spriggs 1997; Summerhayes 2000). The Buang Merabak pottery appeared to be associated with a 10,800 bp ^{14}C determination. In order to investigate this apparent anomaly, the stratigraphy and chronology were re-examined (Leavesley 1996; Leavesley and Allen 1998) and a series of conjoins indicative of the relative stability of the lower layers and some vertical redistribution of material in the upper layers were identified.

Six chronological units were established. Unit 6 began with the first use of the site at 32,000 bp followed by low level use of the site. Units 5 and 4 represented deposition during the LGM followed by a hiatus. Unit 3 included occupation during the Pleistocene/Holocene transition and reflected a time of intensive deposition. Units 2 and 1 reflected mid-Holocene occupation (Leavesley and Allen 1998).

The stone artefact assemblage was technologically uncomplicated consisting almost entirely of small unmodified flakes and angular stone fragments. River cobbles of volcanic origin appear to be the main source of raw materials and the absence of any identifiable cores suggests that the cobbles are broken right down to produce any fortuitous edge, or alternatively such cores are not reduced in this part of the cave. The almost total absence of large flakes in the Pleistocene layers of Buang Merabak distinguishes it from Matenkupkum. It is not clear whether this represents differential access to river cobbles (Leavesley and Allen 1998:73). The nearest source of water-rolled cobbles to Buang Merabak is the nearby river at Dalum village, 2.5 km from Konogusngus (see figure 4).

The concentration of the finest grained material in the lowest levels of the site followed by its apparent replacement with obsidian (Leavesley and Allen 1998:73). This pattern was repeated in other sites in the region (Allen et al. 1989).

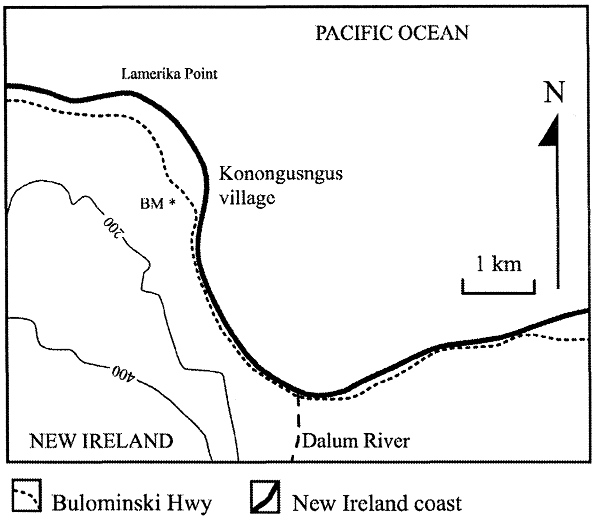

Figure 4: Buang Merabak local topography. BM= Buang Merabak.

The result of the 1985 excavation was a series of analyses that identified the stratigraphic and taphonomic complexities of the deposit with relatively little emphasis on human behaviour. Once these issues were resolved they provided a useful platform from which to begin an assessment of previous models of behaviour proposed from other New Ireland sites and the investigation of behaviour at Buang Merabak itself. A new project began in 2000 in order to focus specifically on human behaviour.

2.3 The 2000 Research

The method and results presented below reflect excavations primarily undertaken during the year 2000 field season complemented by additional material collected during 2001 and 2002. The excavation methodology, stratigraphy and chronology are the basis of the units that underpin the analyses presented in chapters 5 to 6. In particular, the stratigraphic analyses included data derived from colour, calcium carbonate cementation, potential for Hydrogen (pH), sediment particle size and x-ray diffraction analyses. The chronology followed the stratigraphy and provided the temporal parameters of the deposit. Lastly, all the information was brought together and interpreted in the context of a site deposition history.

In 2000, two 1 x 1 m test pits were excavated and nominated TP1A and TP1B as illustrated in figure 5. Test pit 1B was located 20 cm west of Rosenfeld's (1997; Balean 1989) SQ2B. TP1A's north wall conjoined with TP1B's south wall. Both TP1A and TP1B were excavated to bedrock.

In TP1B, bedrock was 2 m below the present cave floor. The excavation proceeded in arbitrary 5 cm spits measured with a dumpy level. Bulk sediment samples were collected from each spit. The deposit was weighed in buckets with a spring balance and dry sieved through a 3 mm mesh.

In 2001, the backfill was removed from the test pits (TP1A and TP1B) and additional sediment samples were collected for laboratory analysis. Further sediment samples were collected by hammering a length of plastic tube into the deposit immediately above the bedrock. Once the tube was full, the end was covered and sealed to avoid exposure to light. Upon completion the site was again backfilled. In 2002, additional contextual information was collected regarding the specific morphology of the third chamber of the cave and its location in the landscape.

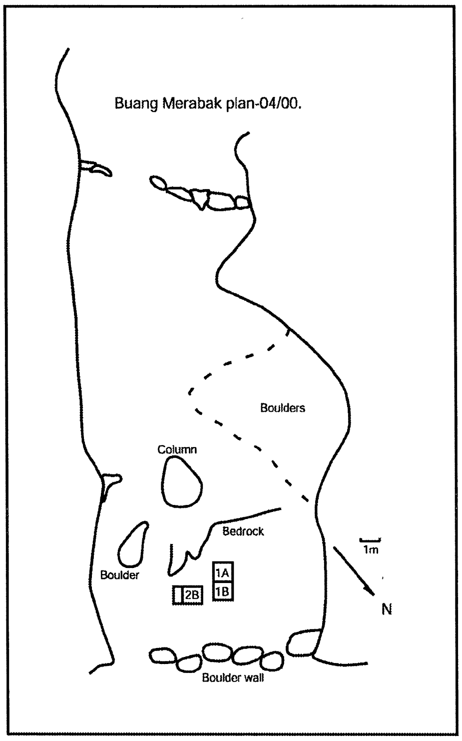

Figure 5: Buang Merabak site plan illustrating the position of the 1985 excavation squares 1A and 2B and the 2000 test pits 1A and 1B.

2.3.2 The 2000 Excavation Stratigraphy

The sediment stratigraphic suggested four units. The uppermost 5-10 cm consisted of fine, grey, unconsolidated sediment that might otherwise be described as topsoil. The second and largest unit consisted of variously 120 cm to140 cm of brown/grey sediment immediately below the topsoil. The third unit consisted of a gradation from grey/brown to orange and was considered a transitional zone. The lowest 15-20 cm consisted of relatively coarse orange sediment. Immediately below the lowest stratigraphic unit was an unevenly weathering bedrock (see figure 6). In order to determine whether there were changes within the layers further colour analysis was undertaken in the laboratory.

2.3.3 The 2000 Excavation Colour Analysis

Depending on specific environmental conditions, sediment colour can alter as a result of post-depositional processes (Spriggs 1999:17) such as moisture content and exposure to light. Sediment colour analysis was undertaken in the laboratory in order to determine any micro-variation in the profile not recorded onsite. The analysis compared a representative sample from each spit with a Munsell colour chart.

All of the samples were collected, stored and transported in the same manner. Immediately upon excavation the sediment was sealed in plastic zip-lock bags and stored in a box until analysis in the School of Archaeology and Anthropology laboratory at ANU. The process of sample collection and storage may subltly alter the results from those that may have been recorded in the field. However, the consistent implementation of collection and storage will have had a uniform impact on the samples. Therefore, the results were seen as a relative indicator of colour change if not an absolute indicator.

The Buang Merabak sediment analysis indicated that the samples graded upwards through the profile from bottom to top, from dark yellowish brown (H10YR 4/4), to brown (H10YR 5/3), through light brownish grey (H10YR 6/2), and dark greyish brown (10YR 4/2) to very dark grey (H2.5Y 3/1) at the surface (Appendix 1).

The colour boundaries occurred between spits 35 and 36, 28 and 29, 21 and 22, 18 and 19 and 10 and 11. In all but one case the changes reflected gradual rather than discrete change suggesting the possibility that they represent post-depositional alteration. Ground water can alter the sediment profile and was therefore investigated through quantification of calcium cementation in the deposit.

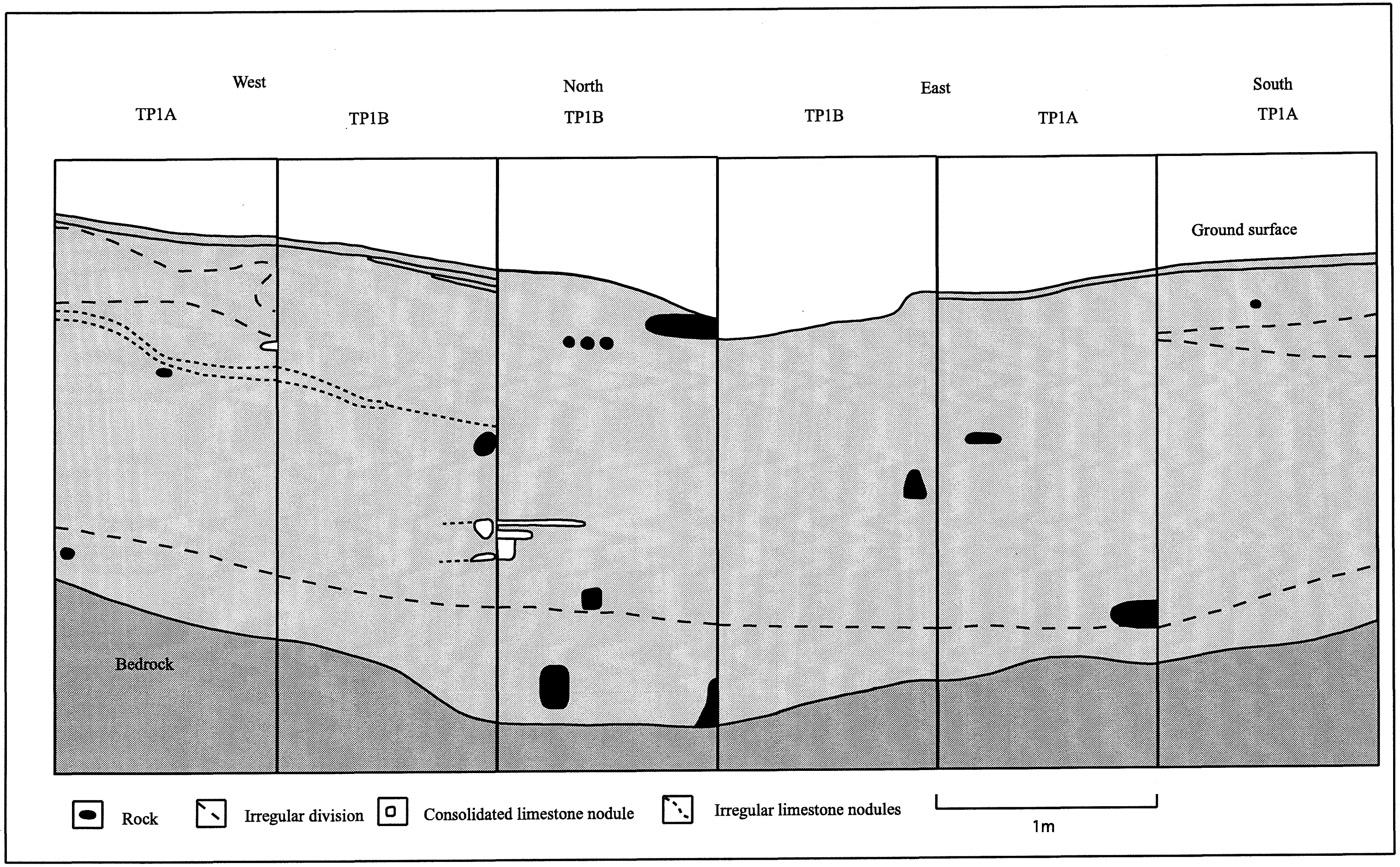

Figure 6 : Buang Merabak stratgraphy from the 2000 excavation.

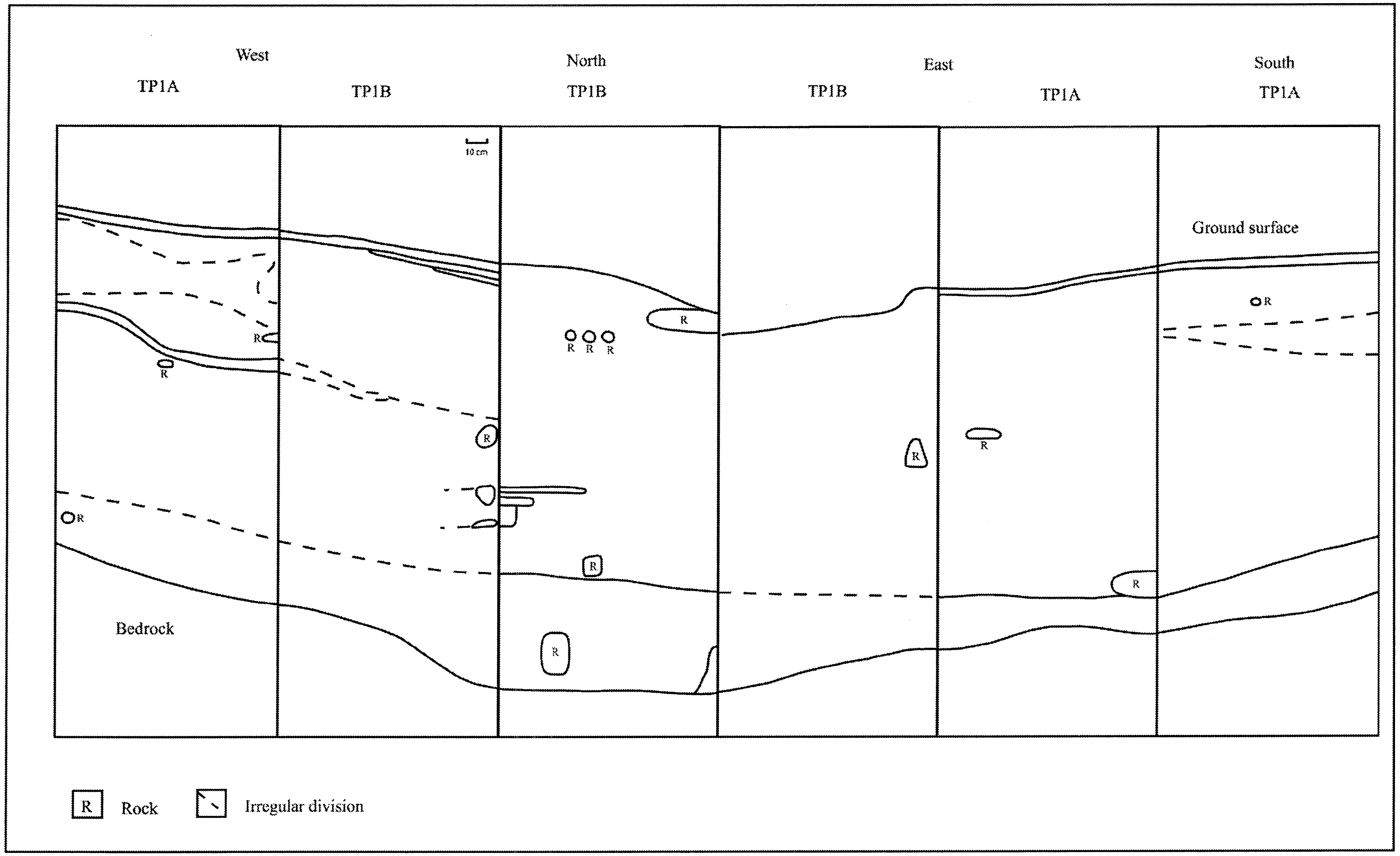

Figure 6: Buang Merabak stratgraphy from the 2000 excavation.

2.3.4 The 2000 Excavation Calcium Cementation Distribution

The extent of cemented material within the deposit indicates substantial post-depositional calcification has occurred at the site. Calcification occurred as a result of the infiltration of water into calcareous sediments and the subsequent cementation of the sediment particles to each other and to any shell, bone, plant material or stone artefacts that were present. The resulting lumps of calcrete consist of a concentration of sediment and include shell, bones and stone artefacts in a matrix of calcrete cement. The calcrete occurs in lenses across the test pits and was collected and weighed independently of the rest of the assemblage.

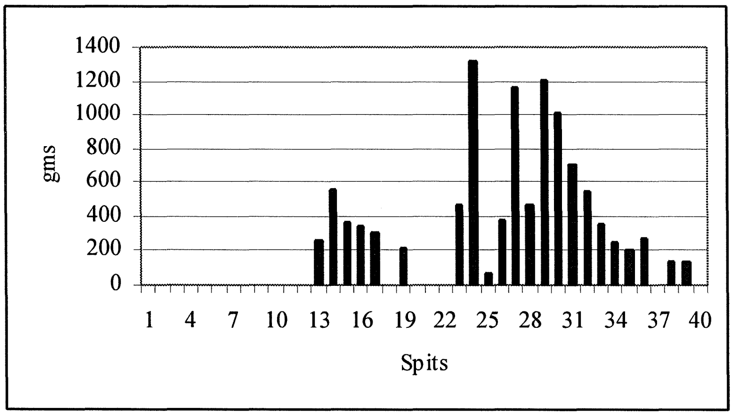

Figure 7: Weight (grams) of calcreted nodules per spit in Buang Merabak TP1B.

The distribution and location of calcrete nodules within the site profile were considered in two ways. First, the illustrated stratigraphy highlights five lenses of calcified sediment across the profile as seen in figure 6. Secondly, figure 7 indicates three general spikes (peaks in accumulation) of calcification in spits 14, 24 and 29. The nature of the lenses in conjunction with the excavation procedure may partly explain the convoluted nature of the graphed data. The lenses themselves were made up of a higher density of calcified nodules that were not clearly distinguishable on the basis of colour. The distinction became clear through the relative increase in the observable size (during excavation) and quantity of the cemented nodules. The lenses themselves, indicated in figure 6, sloped down to the front, mouth or north end of the test pits. As described above, the site was excavated in arbitrary 5 cm horizontal spits and within this context, the lenses were not clearly distinct enough to be interpreted as stratigraphic boundaries during excavation and were excavated at a rate of between 15-20% per spit over a depth of 5-7 spits. Therefore, figure 7 is a better indicator of the distribution of the post-depositional cemented lenses than the data in figure 6.

The presence of calcified lenses is an indication of water infiltrating the deposit. When a cave environment is in stasis water can pool on the surface of the deposit releasing any $CaCO^3$ which subsequently collects on the ground and solidifies. If the process continues for long enough, it manifests itself as a single 'crust' across the top of the sediment known as flowstone. Calcification represents a stasis within the cave environment and the process of other (non-$CaCO^3$) sediment accumulation. The presence of calcified nodules in the Buang Merabak deposit suggested periods of relative depositional stasis. The calcification occurred as irregular lumps rather than as flow-stone indicating the degree of stasis may have been relatively short-lived or interrupted.

The calcified layers centre on spits 29, 24 and 14 and fit irregularly into the Units. The lowest calcified layer occurred in close proximity to the boundary between Units 3 and 4 and suggests a temporal hiatus. The middle calcified layer occurred in the middle of Unit 3 and the third occurred in the middle of Unit 2. Calcrete was a visible characteristic of natural processes on the deposit. Other non-visible factors such as pH can provide indications of stratigraphic divisions.

2.3.5 The 2000 Excavation Sediment Potential of Hydrogen (pH)

The overall chemical balance of the sediment is instructive in understanding the stratigraphy and taphonomy of the site and is determined by measuring the pH of the sediment. Sediment pH was an expression of the concentration of ionised hydrogen and is indicative of the degree of acidity or alkalinity of the sediment. Soil sediment contained both free positively charged hydrogen (H^+) ions and negatively charged hydroxyl (OH.) ions. When the balance of these ions was even, the sediment was considered neutral. An excess of H^+ ions produces acid sediment and an excess of OH. ions produces alkaline sediment. Absolute neutrality is 7.07 and is central to a graduated scale from acid at -0.3 and alkaline at 14.5.

The sediment pH was measured using a standard garden pH tester in accordance with the instructions. The samples used for this analysis came from TP1B (Appendix 1). The accuracy of the results may alter depending on the amount of time after excavation that the measurements were taken because the sediment moisture levels and biological activity may alter the pH value of the sediment and were taken into consideration for interpretation. However, all samples were subjected to the same process of collection immediately upon excavation, sealed in a zip lock plastic bag and stored in a box until analyses were undertaken within laboratory conditions.

The pH values represent the accumulation of at least three separate processes. First, they reflect the inherited pH value of the material prior to deposition. Secondly, the pH value can alter, while *in situ*, depending on the rate of geochemical changes that occurred over time. And thirdly, the values may have altered while in storage prior to laboratory analysis. Therefore, in everything other than the general trends, the values were taken as relative indicators of change rather than absolute values.

Overall the entire sediment column was alkaline. The trend was from mid-alkalinity (pH=10) at the base of the deposit to low-alkalinity (pH=8.5) at the top. Spits 40 to 29 had values of 10. Spits 28 to 24 were either 9 or 10. Spits 23 to 20 had values of 10. Spit 19 had a value of 9.5. Spits 18 to 3 had values of 8.5 and spits 2 and 1 were not analysed.

The results were relatively high and probably reflect a higher rate of calcium and magnesium in the sediment and maybe a reflection of one or both, of two factors. First, the sediment was collected from a limestone cave predominantly consisting of calcium carbonate ($CaCO^3$), which is highly alkaline. Secondly, the relatively high alkalinity may reflect the fact that the pH was recorded in the laboratory rather than *in situ* (as discussed above).

It was instructive to note that the results were internally consistent as demonstrated by their gradation over time and depth from 10 at the base of the deposit to 8.5 at the top (Appendix 1). The results also indicate consistency and change within and between specific groups of spits. Adjoining spits with the same pH value were grouped together as units of consistency and adjoining spits with different pH values were considered as boundaries. Spits 40 to 29 had a value of 10 and represent a unit of consistency. Spit 28 had a pH value of 9 and represented change. Spits 28 to 24 had alternating values of either 10 or 9 and were interpreted as representing one of two things. First, each spit could represent an individual unit or collectively considered as a single variable unit. Spits 23 to 20 all had pH values of 10 and could be considered as an individual unit. Spit 19 had a pH value of 9.5-10 and spits 18 to 3 had values of 8.5. In this context, spit 19 was considered as a mixture of the lower (spit 23 to 20) unit with the upper (spit 18 to 3) unit.

While pH primarily reflected post-depositional processes, it suggested that once the sediment was deposited it was subject to a relatively uniform process throughout the column. Another way of testing stratigraphic divisions was sediment particle size analysis.

2.3.6 The 2000 Excavation Sediment Particle Size Analysis

Sediment samples were analysed for particle size following the methodology by Folk (1961) for the purposes of internal uniformity and external consistency. During excavation sediment samples were collected from each spit (at an average weight of 195 gm per sample), from both test pits. The sediment was weighed using an ISSCO model 3000 electronic balance and washed in order to achieve disaggregation. The <63 μ particles were separated by decanting the suspended sediment from one beaker into another. Upon completion the remaining sediment was placed in an oven at 32°C until dry. It was then put into a set of Endicott nested sieves with fractions of 500 μ, 250 μ, 125 μ and 63 μ respectively. The sieves were placed on an Endicott shaker with the timer set at ten minutes. Upon completion the sediment was emptied from each sieve and weighed again. The sieve fractions correspond with standard regolith terminology as seen in table 7.

Table 7: The sieve fraction for each particle size

Particle size	**Sieve fraction**
Coarse sand	>500 μ
Medium sand	250-500 μ
Fine sand	125-150 μ
Very fine sand	63-125 μ
Clay	<63 μ
Fine clay	Suspension

Overall the sediment showed a high component of clay (<63 μ) and smaller particles (Appendix 2). The average percentage of sediment per spit classified as clay or smaller was 44.42% with a range from 14.24% in spit 39 to 60.8% in spit 8.

The particle size analysis results reflected three different trends (see figure 8). First, sediment in the medium sand (250-500 μ) and fine sand (125-250 μ) size classes constituted a relatively high percentage of sediment between spit 39 and spit 34. The percentage of sediment remained relatively stable but at a lower quantity for this size fraction for the remainder of the samples between spit 31 and spit 6. Secondly, the very fine sand (125-63 μ) and coarse silt to very fine silt (<63 μ) reflect a series of units separated by four troughs in the percentage of these particle sizes. The troughs occurred at spit 11, spit 20, spit 29 and spit 34. Thirdly, the coarse sand and larger (>500 μ), and the clay (separated by suspension) reflected a relatively random distribution.

The sediment particle size data is conventionally used for analysis of alluvial deposits to investigate sediment origin through looking at mechanisms of transportation. Sediment origin can also be investigated through XRD analysis.

2.3.7 The 2000 Excavation X-Ray Diffraction (XRD)

X-ray diffraction identifies sediment mineral composition. The analysis was undertaken for two reasons. First, to determine if the deposit was derived from a single source and secondly, to determine if the sediment colour was a reflection of post-depositional sediment alteration processes that resulted in the homogenisation of the sediment colour profile. In this context XRD was particularly appropriate because it characterised sediment based on mineral content and was not dependent upon colour.

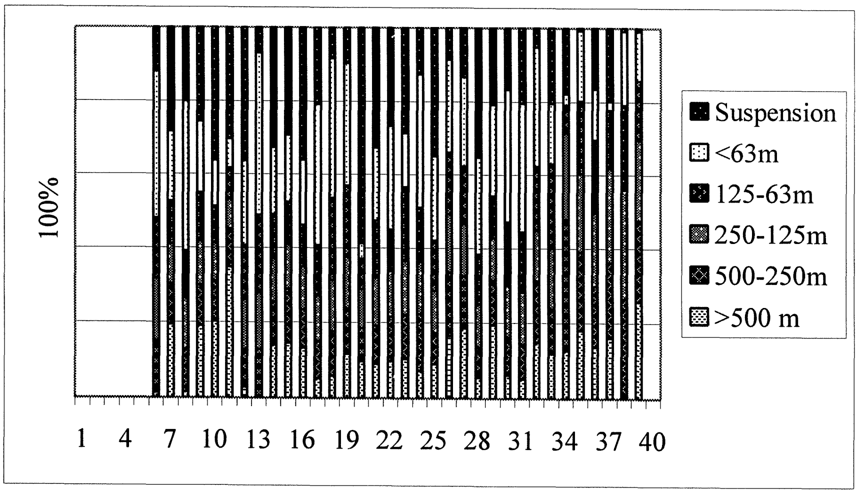

Figure 8: Buang Merabak TP1B sediment particle size analysis (see Appendix 2). m=microns.

Five samples, from spits 12, 15, 23, 33 and 40, were submitted for XRD analysis. The analysis identified nine separate minerals listed in table 8 (see Appendix 3). All but woodhouseite were consistent with previous reports of New Ireland geology (Stewart and Sandy 1986).

Calcite and aragonite were consistent with the limestone in which Buang Merabak was located. The presence of apatite (a phosphorous rich mineral) was most likely the result of the accumulation of guano. A variety of Micropteroptera species inhabits the cave and guano was clearly evident in the all three chambers. Quartzite did not exceed the error rate of 2.5% in any sample but was common in small amounts in limestone. Further analyses will determine if it definitely existed in the sediment. Kaolinite occurred at less than 2.5% in all but spit 40 and was commonly considered to be the product of weathering calcite. Biotite did not exceed the error of 2.5% in any sample and therefore, only further analyses will determine if it definitely existed in the sediment. Biotite, magnetite and muscovite were usually associated with volcanics or impure limestone. The Lelet Limestone was described as 'pure' on the basis of colour and description (Hohnen 1978:9). Future chemical characterisation may alter this interpretation, but, on present evidence the minerals (biotite, magnetite and muscovite) must be considered detrital, possibly derived from the Jaulu volcanic. The identification of woodhouseite was more problematic. Although it occurred, in spit 40, well above the error rate at 10.9%, the mineral appeared to be out of place in the PNG geological context. Therefore, its presence was interpreted as representing the potential for one, or a variety of minerals, that were not easily identified by XRD analysis to exist in spit 40.

Table 8: List of the mineral identified in the Buang Merabak samples by XRD analysis. Calcite and Aragonite are two polymorphs of calcium carbonate commonly found in nature (Deer et al. 1992).

Mineral	**Code**	**Comment**
Calcite	$CaCO_3$	Calcium carbonate, limestone.
Apatite	$Ca_5 (PO_4)_3 (OH,F,Cl,)$	Possibly derived from guano (and bone).
Aragonite	$CaCO_3$	Calcium carbonate, limestone.
Quartzite	SiO_2	Silica.
Kaolinite	$Al_4 [Si_4O_{10}] (OH)_8$	Hydrous aluminium silicate; clay.
Muscovite	$K_2Al_4 [Si_6Al_2O_{20}] (OH,F)_4$	Hydrous potassium aluminium silicate.
Magnetite	$Fe^{2+} Fe_2^{3+} O_4$	Iron oxide; alluvial & marine sands.
Biotite	$K_2 (Mg,Fe^{2+})_{6-4} (Fe^{3+},Al,Ti)_{0-2} [Si_{6-5}Al_{2-3} O_{20}] (OH,F)_4$	Hydrous potassium aluminium silicate.
Woodhouseite	$CaAl_3 (PO_4)(SO_4)(OH)_6$	Calcium aluminium phosphate sulphate hydroxide.

The XRD data reflected change over time of the mineral composition of the Buang Merabak deposit (Appendix 3). The results from spits 12, 15, 23 and 33 appeared relatively similar and contrast with spit 40. The most common mineral present in the Buang Merabak samples was calcite. It constituted over 80% of the samples from Spits 12, 15, 23 and 33 and 42% of spit 40. The latter contained a relative increase in Kaolin (and the so-called woodhouseite). The kaolin may have developed as a result of weathering through direct exposure to the atmosphere. Its presence in spit 40 suggested that after the deposition of the basal unit there was a hiatus in deposition followed by a period of weathering and possibly erosion before deposition resumed.

The XRD data supported the division of the stratigraphy into two parts as indicated by the *in situ* and laboratory colour data. The only difference was the increase in calcite from 40% of the spit 40 sample to 80% of the samples for spit 12, 15, 23, and 33 (see figure 9). The reduction may reflect the process of sediment degradation. The XRD data therefore suggested there was little change in the source of sediment over time.

The stratigraphic analyses indicate a complex depositional history. In order to determine the rate of accumulation ^{14}C was utilized.

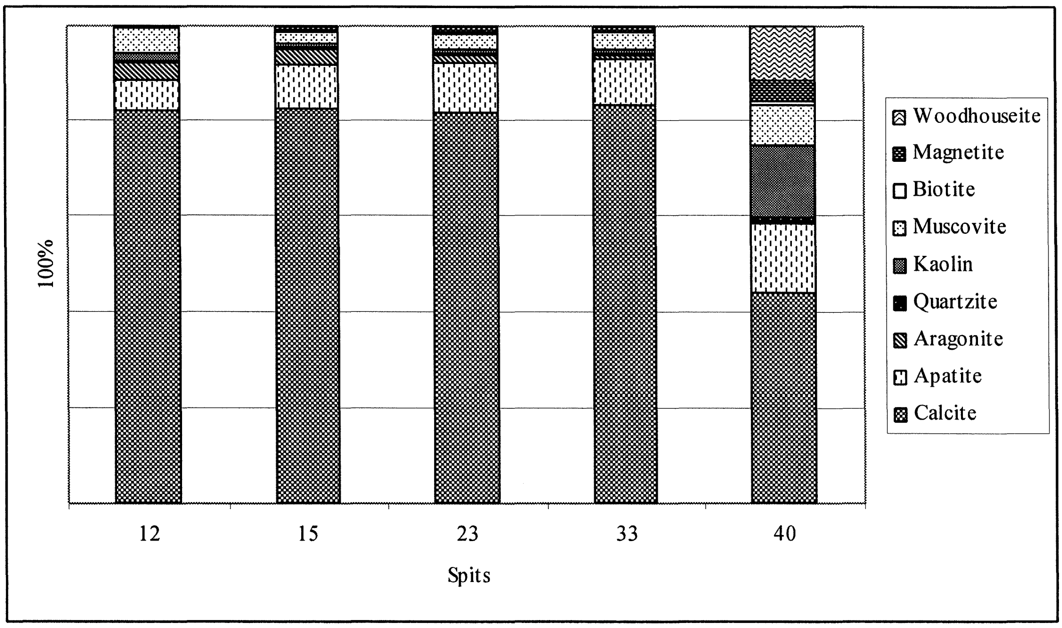

Figure 9: Buang Merabak TP1B XRD data from spits 12, 15, 23, 33 and 40 (see Appendix 3).

2.3.8 The 2000 Excavation Chronology

Twenty-eight shell and charcoal samples were collected during excavation and submitted for ^{14}C determination. Shell was the preferred sample material due to the low quantity of observable charcoal (see table 6) in the deposit and because it is more consistent (Meltzer and Mead 1985). Where possible, the same genus (*Turbo* sp.) was utilized in order to reduce anomalies such as the impact of variable carbon uptake between shell taxa. The determinations were derived from three sets of procedures. Four determinations were run by Mike Bird, seven by John Chappell and the remainder as conventional determinations at the ANU ^{14}C laboratory.

2.3.9 The 2000 Excavation Chronology Method

Bird prepared samples ANUA-15808, ANUA-15809, ANUA-16302 and ANUA-16303 and AMS measurements were recorded at the ANU AMS facility by Keith Fifield. The samples consisted of two complete shells, one *Turbo argyrostoma* and the other *Purpura persica*. Prior to analysis, ~500mg of carbonate was cut from the columella of each shell, and the surface cleaned by dissolving approximately 50% of the sample in dilute hydrochloric acid. The sample was then washed with milliQ water, dried, and loaded, along with ~5mls of anhydrous phosphoric acid into the low-blank target preparation line at the Research School of Earth Sciences, ANU (Bird et al. 1999).

After evacuation of the extraction line, the phosphoric acid was added incrementally, and the carbon dioxide released from the sample was collected sequentially during the dissolution. Two graphite targets were made from each sample, one from the carbon dioxide liberated at ~40-60% dissolution, and a second at ~80-95% dissolution. The $^{14}C/^{13}C$ ratios of the graphite targets were measured by accelerator mass spectrometry on the 14UD accelerator at the ANU.

The second series of eight shell samples was run under the supervision of John Chappell. One specimen was a *Turbo* sp. body shell and six were *Turbo* sp. opercula. Each sample was entirely dissolved in HCl and the produced CO_2 was converted to benzene for conventional ^{14}C dating in the ANU Radiocarbon Laboratory, following methods described by Gupta and Polach (1985). It is well known that shell dates may be unreliable if the shells contain any traces of secondary or replacement carbonate and therefore the shells were analysed for evidence of digenesis. Each of the specimens ANU-11556-2, ANU-11556-3, ANU-11556-4, ANU-11556-5 and ANU-11556-6 was cut in half and a thin section was prepared from one half. An aliquot of the other half was crushed, cleaned and digested to produce CO_2, which was reduced with granulated iron and hydrogen to graphite. After pressing to form AMS targets, samples were measured in the ANU AMS facility (Bird et al. 1999). The remaining 16 determinations were provided by the Centre for Archaeological Research and were run at the ANU radiocarbon dating laboratory by conventional means following the standard techniques.

All the ^{14}C determinations that were run as part of this analysis are listed in table 9. They range from 40,000 bp to 1800 bp and predominantly represent a direct relation between age and depth. The post 20,000 bp estimates were calibrated using the Calib 4.3 calibration program (Stuiver and Reimer 1993). The pre-20,000 bp determinations were not calibrated because they were beyond the temporal limit of the calibration program. For the purpose of remaining consistent they were presented in their uncalibrated (bp) form throughout this dissertation (see table 9).

The two charcoal determinations (ANU-11314 and ANU-11312) were distinctively younger than overlying samples and do not fit the sequence. The 1985 excavation charcoal determinations were similar in character and were interpreted as anomalous (Rosenfeld 1997:215). Therefore, these data, in conjunction with Rosenfeld's earlier determinations (Leavesley 1996), suggest the possibility that the Buang Merabak charcoal may have been subjected to, as yet unknown, post-depositional chemical alteration.

Table 9: Lists the radiocarbon determinations for Buang Merabak (* and ^ denote single shells utilized for two determinations). Conv. = conventional ^{14}C determination. The sample material category includes the number of shell fragments utilized where appropriate.

Test pit	**Spit**	**Sample material**	**Lab. Code**	**Age (bp)**	**Calibration (BP) /comment**
TP1A	9	*Turbo argystroma*	ANU-11466	10,660±90	Conv. 12,173 (11,831) 11,494
TP1A	11	*Turbo* sp. opercula (x5)	ANU-11467	10,500±100	Conv. 11,907 (11,484) 10,887
TP1B	6	*Turbo* sp. opercula (x1)	ANU-11557	1800±70	Conv. 1403 (1328) 1277
TP1B	8	*Turbo* sp. opercula (x4)	ANU-11558	2310±70	Conv. 1993 (1997) 1839
TP1B	9	Charcoal	ANU-11314	170±80	Conv. anomalous (?)

TP1B	11	*Turbo* sp. opercula (x7)	ANU-11465	3420±60	Conv. 3356 (3311) 3219
TP1B	12	Charcoal	ANU-11312	550±130	Conv. 303 (235) 0
TP1B	13	*Turbo* sp. opercula (x5)	ANU-11543	7780±80	Conv. 8333 (8217) 8156
TP1B	15	*Turbo* sp. opercula (x3)	ANU-11541	10,830±120	Conv. 12,302 (12,225) 12,152
TP1B	17	*Turbo* sp. opercula (x4)	ANU-11540	11,740±90	Conv. 13,749 (13,164) 13,011
TP1B	19	*Turbo* sp. opercula (x9)	ANU-11349	17,000±130	Conv. 20,015 (19,666) 19,331
TP1B	22	*Turbo* sp. opercula (x4)	ANU-11350	19,930±150	Conv. 23,480 (23,038) 22,644
TP1B	24	*Turbo* sp. opercula (x4)	ANU-11542	18,830±190	Conv. 22,179 (21,772) 21,379
TP1B	27	*Turbo* sp. columnella (x1)	ANU-11642	17,340±190	Conv. 20,444 (20,058) 19,681
TP1B	29	*Turbo* sp. columnella (x1)	ANU-11643	27,190±430	Conv.
TP1B	32	*Turbo* sp. opercula (x2)	ANU-11644	31,740±640	Conv.
TP1B	35	*Turbo* sp. opercula (x8)	ANU-11351	32,930±550	Conv.
TP1B	39	*Turbo* sp. body (x1)	ANU-11555	32,430±420	Conv.
TP1B	40	*Turbo* sp. operculum (x1)	ANU-11556-1	29,430±760	Conv.
TP1B	40	*Turbo* sp. opercula (x1)	ANU-11556-3	30,160±70	AMS (see Table 10)
TP1B	40	*Turbo* sp. opercula (x1)	ANU-11556-4a ANU-11556-4b	31,384±80 31,633	AMS; paired ages; altered (see Table 10)
TP1B	40	*Turbo* sp. opercula (x1)	ANU-11556-5	32,766±50	AMS; altered (see Table 10)
TP1B	40	**Purpura persica*	ANUA-16303	32,440±570	83-89% (M. Bird)
TP1B	40	**Purpura persica*	ANUA-16302	33,270±560	63-69% (M. Bird)
TP1B	40	*Turbo* sp. opercula (x1)	ANU-11556-2	34,079±60	AMS; altered (see Table 10)
TP1B	40	*Turbo* sp. opercula (x1)	ANU-11556-6	38,760±100	AMS; altered (see Table 10)
TP1B	40	^*Turbo argystroma*	ANUA-15808	39,090±550	42-59% (M. Bird)
TP1B	40	^*Turbo argystroma*	ANUA-15809	40,090±550	95-99% (M. Bird)

At the base of the site in spit 40, there were two determinations derived from a *Turbo argystroma* that statistically overlap with a central value of 39,590±550 bp (ANUA-15808 and ANUA-15809) and two ages on a *Purpura persica* that also overlap with a central value of 32,355±550 bp (ANUA-16302 and ANUA-16303). The difference of ~7000 years between these two specimens was unexpected because they were from the same spit in the excavation (Leavesley et al. 2002).

Table 10: Results of analysis, undertaken by John Chappell, to identify chemical alteration in the shell samples submitted for radiocarbon analysis.

Lab. Code	**Slide Section**	**Alteration**	**Chappell Comment**
ANU-11556-2	Transverse cut through side of operculum.	Negligible alteration.	Reliable
ANU-11556-3	Oblique view through growth bands.	No coarse alteration but discoloured and micritic.	Unreliable
ANU-11556-4	Transverse cut near centre of operculum.	Micritic near base & apex, two secondary calcite veins.	Unreliable
ANU-11556-5	Oblique of uncertain orientation.	Burned, altered with calcite filled cavities.	Quite unreliable
ANU-11556-6	Transverse section.	Negligible alteration in growth bands, marginal corrosion, removed in ^{14}C prep.	Reliable

Microscopic thin-section examination of the *Turbo* sp. opercula from spit 40 revealed significant differences between specimens as summarised in table 10. Three specimens were significantly altered. In ANU-1155-3 and ANU-11556-4, the original dense, fine texture of the operculum was locally altered to fine, micritic calcite and crossed by thin veins of secondary calcite, while ANU-11556-5 was strongly discoloured, suggesting burning, and includes cavities filled with relatively coarse calcite. The radiocarbon ages obtained for all three were judged to be unreliable. By way of contrast, samples ANU-11556-2 and ANU-11556-6 show very little evidence of diagenesis and their radiocarbon ages were judged to be reliable (Leavesley and Chappell 2004).

The results from spit 40 showed an age-range of over 11,000 years, from 27,500±580 bp (ANU-11556-1) to 38,760±100 bp (ANU-11556-6) and the results from spit 39 lie within this range. The spread of ages implied either that deposit of spits 39 and 40 accumulated over a considerable period and was also mixed, or that at least some of the radiocarbon dates differ from the true sample ages, owing to post-depositional contamination. As the specimens all were thoroughly cleaned, contamination, if present, was likely to have been introduced through diagenesis

Sample ANU-11556-6 gave an age of 38,760±100 bp, which was in good agreement with the mean result of 39,590 bp for ANUA-15808/15809, reported by Leavesley et al. (2002) (Table 9). Together, the results indicated that the site was occupied at 39,500 bp. However, accumulation of the basal part of the deposit (spit 40) appeared to have been very slow, and mixing appeared to have occurred, as there was no vertical separation between these samples and ANU-11556-2, which also was judged to be reliable but gave an age of 34,080±60.

The ^{14}C data in table 10 further demonstrated that ANUA-15808 and ANUA-15809 reflected cultural midden material rather than natural shell. The table 10 samples were derived from a matrix of human food refuse and stone artefacts. While the Leavesley et al. (2002) samples are near-complete shells the determinations reported here were derived from opercula. The opercula indicate the shells were brought to the cave while the opercula were still attached. Opercula do not stay attached to their shell for long after the shellfish die suggesting that the animal was alive when it arrived at the site. The presence of the opercula suggested they were removed from the shell within the cave. This is because opercula are attached to the body of the shell by a muscle that remains so while the animal is alive. When the animal dies the opercula is released. This process was consistent with human shellfish gathering in which they were collected live and transported to their place of consumption before being cooked and eaten.

The presence of opercula in the deposit also reduced the likelihood of 'old shell' being brought to the cave with the first human inhabitants. The likelihood of 'old shell' surviving in a natural (non-sedimentary) coastal environment was considered low. However, it was also unlikely that *Turbo* sp. would survive with opercula intact to be found 4000 years later and subsequently taken to the cave to be mixed with the *in situ* midden material. Therefore, it was considered that the first occupants arrived at the site at 39,950 bp and brought amongst other food and stone artefact resources live shellfish that were subsequently consumed at the site.

The period 38,500 bp to 34,500 bp was not represented in the radiocarbon sequence. This was attributed to a number of possible reasons including sampling, a depositional discontinuity representing an occupational hiatus, a phase of erosion, or a combination of both. There was no stratigraphic evidence of erosion suggesting it was unlikely that material was removed from the site. In the 10,000 ^{14}C years prior to 30,000 bp, levels of atmospheric carbon were little known but appeared relatively erratic (Chappell pers. comm.). Therefore, until more research is undertaken, the possibility that the apparent hiatus was a product of the differential atmospheric carbon cannot be ruled out. In the meantime, the most parsimonious interpretation was that this period represents an occupational hiatus. Similar hiatuses later in the sequence were interpreted in the same way.

There were eleven determinations from ten samples ranging from 27,190±430 bp to 34,079±60 bp spanning a range of 6900 ^{14}C years. Three of the eleven determinations were not in chronological order.

The lack of any determinations representing the period from 27,000 bp to 20,000 bp suggested a non-continuous deposition reflecting an occupational hiatus.

The next four determinations were ANU-11349, ANU-11350, ANU-11542 and ANU-11642. Although two were inverted all four determinations were between 17,000±130 bp and 19,930±150 bp spanning a range of 2930 ^{14}C years.

There were no determinations that fall within the period from 17,000 bp to 12,000 bp. This suggests a depositional discontinuity reflecting an occupational hiatus. Evidence from Matenkupkum had a similar temporal gap suggesting the potential for a southern New Ireland regional post-depositional phenomenon or a behavioural hiatus in southern regions cave sites during this period.

There were three determinations spanning the Pleistocene/Holocene transition including ANU-11540, ANU-11541 and ANU-11543. They were between 7780±80 bp and 11,740±90 bp, a range of 3960 ^{14}C years and were in stratigraphic and chronological order. There were also two determinations from the adjacent test pit TP1A. The determinations ANU-11466 and ANU-11467 overlap at 1σ. They represent an age of 10,500 bp across spits 9 to 11. The TP1A determinations were slightly higher up the stratigraphic sequence than those from TP1B suggesting that the unit had variable depth across the site.

The lack of any determinations representing the period from 7500 bp to 3500 bp suggested another discontinuity of deposition in the sequence.

Two determinations, ANU-11557 and ANU-11558, were the youngest determinations for TP1A and TP1B. In close proximity was ANU-11465 reflecting an age of 3420±60 bp. It was vertically separated by between 10 and 20 cm from the two other determinations (ANU-11466 and ANU-11467). Following Leavesley and Allen (1998) this was interpreted as reflecting downward vertical redistribution into an adjoining lower temporal unit. Therefore, Unit 1 had evidence of mixing with Unit 2 but in itself represents a period of approximately 1500 ^{14}C years (2000 Cal. years) from 3400 bp until 1800 bp.

3. CHRONOLOGY AS UNITS

The stratigraphy and chronology provide the basis for the designation of units. The units in table 11 are based on the radiocarbon chronology and stratigraphy described above. The artefacts from within each unit are interpreted in terms of human behaviour and compared with those in other units in order to investigate the nature of change over time.

Table 11: Buang Merabak Units.

Unit	Spits	Age bp	Age Cal. BP
1	1 to 8	1800 to 3500	1300 to 3300
2	9 to 17	7000 to 12,000	8200 to 13,150
3	18 to 27	17,000 to 20,000	19,650 to 23,050
4	28 to 40	27,000 to 39,590	N/A

For the purposes of analysis they will considered as 'time averaged' units (Behrensmeyer 1987). As described above the site was excavated in sequential spits from top to bottom. The spits were divided into units listed in table 11. Spits 1 to 5 were grouped with spits 6 to 8 because the sediment analysis (see Table 12) suggests they are homogenous in terms of colour and pH value.

Unit 4 represents the oldest evidence of human behavior in the Bismarck Archipelago and represents 12,590 ^{14}C years. The Units 3 to 1 represent 10,350 calibrated years equivalent to 8970 ^{14}C years. Collectively the four Units represent 21,560 ^{14}C years, slightly more than half the possible period of human occupation in New Ireland. Although extending the antiquity, the sequence was consistent with previous chronological analyses of the site (Leavesley and Allen 1998) and the region (Specht in press) providing indirect support for its validity.

Table 12: Summary of sediment deposition history at Buang Merabak. XRD* 1 = 82-83% calcite with minor apatite and muscovite, 2= 43% calcite with 14% apatite and kaolin (data in Appendices 1, 2 and 3).

Spits	Munsell Colour	pH	125-63µ Particle size	XRD*	Shell Ages (bp)	Unit
1	N/A	N/A	-	-		1
2	N/A	N/A	-	-		1
3	Very Dark Grey	8.5	-	-		1
4	Dark Grey	8.5	-	-		1
5	Dark Greyish Brown	8.5	-	-		1
6	Dark Grey	8.5	16.19	-	1800±70	1
7	Dark Grey	8.5	11.62	-		1
8	Dark Greyish Brown	8.5	12.75	-	2310±70	1
9	Dark Grey	8.5	13.18	-	10,660±90	2
10	Dark Grey	8.5	9.91	-		2
11	Dark Greyish Brown	8.5	8.43	-	10,500±100, 3420±60	2
12	Very Dark Greyish Brown	8.5	14.48	1		2
13	Dark Greyish Brown	8.5	20.86	-	7780±80	2
14	Dark Greyish Brown	8.5	11.94	-		2
15	Dark Greyish Brown	8.5	11.48	1	10,830±120	2
16	Dark Greyish Brown	8.5	11.43	-		2
17	Dark Greyish Brown	8.5	13.63	-	11,740±90	2
18	Dark Greyish Brown	8.5	22.30	-		3
19	Greyish Brown	9.5-10	19.37	-	17,000±130	3
20	Greyish Brown	10	8.08	-		3
21	Greyish Brown	10	15.48	-		3
22	Light Brownish Grey	10	11.41	-	19,930±150	3
23	Light Brownish Grey	10	20.09	1		3
24	Light Brownish Grey	9	14.88	-	18,830±190	3
25	Light Brownish Grey	10	13.80	-		3
26	Greyish Brown	9	16.83	-		3
27	Light Brownish Grey	10	15.70	-	17,340±190	3
28	Light Brownish Grey	9	12.90	-		4
29	Brown	10	10.61	-	27,190±430	4
30	Brown	10	17.19	-		4
31	Brown	10	16.30	-		4
32	Brown	10	17.31	-	31,740±640	4
33	Brown	10	22.85	1		4
34	Brown	10	7.65	-		4

35	Brown	10	20.04	-	32,930±550	4
36	Yellowish Brown	10	19.70	-		4
37	Yellowish Brown	10	15.76	-		4
38	Dark Yellowish Brown	10	23.37	-		4
39	Dark Yellowish Brown	10	16.51	-	32,430±420	4
40	Dark Yellowish Brown	10	-	2	29,430±760 to 40,090±550 (10 dates)	4

Post-depositional site formation processes have a major impact on archaeological sites. In order to test the validity of the units they are compared and discussed in the context of the site history including colour, post-depositional calcification, potential for Hydrogen (pH), sediment particle size and X-Ray Diffraction (XRD) data.

4. SITE DEPOSITIONAL HISTORY

The site history reflects the nature of the build-up of the deposit in the cave. It is described within the framework of the units and draws together all the stratigraphic data described above. Table 12 summarizes the data in the form of boundaries and affinities within the deposit. The morphology of the cave slopes down towards the front of the first chamber indicating the general route of sediment movement within the cave. The percentage of sediment particles greater than 125 μ dropped over time and suggested a lower energy natural depositional environment in conjunction with human behaviour in Unit 4.

Unit 4 coincides with the first human occupation of the cave at 39,590 bp and included the basal 60 cm of deposit. It accumulated at a rate of 4.5 cm per 1000 ^{14}C years and was the slowest of all the units (see Table 13). It represented half the rate of the next slowest unit and a quarter of the rate of the fastest. The unit changed colour in the middle and was, from the bottom, H10YR 4/4 through H10YR 5/3 to HYR 6/2. The colour of the lowest 25 cm suggested oxidation that commonly occurs with regular or continuous contact with water. The unit also contained 14.7% kaolin that was common in sediments that were exposed to long periods of degradation through exposure to air. The presence of kaolin suggested a slow build-up, if not a series of hiatuses in deposition. The ^{14}C chronology supported the possibility of one or a number of hiatuses as there was an apparent radiocarbon temporal gap between 38,000 bp and 34,100 bp. The sediment was high in calcium carbonate consistent with *in situ* weathering of cave deposits. The percentage of sediment particles greater than 125 μ was high compared to any other time. The upper 35 cm of Unit 4 graded to brown suggesting relatively less exposure to water than the sediment below and indicated the movement of water along the bedrock. The entire deposit was alkaline reflecting high calcite content, which was a feature of the entire deposit. The second chamber was higher than the first and therefore cannot be discounted as a subsidiary sediment source. The determinations covered the period from 32, 000 bp to 27,000 bp and partially overlap with the previous phase. The inverted radiocarbon determinations support the possibility of some admixture.

Table 13: indicates the rate of deposition at Buang Merabak.

Unit	**Years bp**	**Years BP**	**Volume**	**Vol. per 1000 years bp**
1	1700	2000	0.4 m^3	0.0235 m^3
2	5000	4950	0.45 m^3	0.09 m^3
3	3000	3400	0.5 m^3	0.16 m^3
4	12,500	N/A	0.65 m^3	0.052 m^3

The radiocarbon chronology indicates a temporal gap from 27,000 bp to 20,000 bp that without reliable calibration is difficult to interpret. Prior to 20,000 bp the levels of radiocarbon in the atmosphere are relatively variable and therefore without reliable calibration it is not clear whether the difference between these radiocarbon determinations represents the equivalent number of calendar years. The boundary between Units 3 and 4 coincides with a horizontally bedded, loose series of calcrete nodules probably representing a discrete layer of post-depositional cementation.

Unit 3 represented the 3000 ^{14}C years (3400 calibrated years) from 20,000 bp to 17,000 bp. All four determinations were extremely similar and did not overlap with the determinations above or below them. They also reflected a trend identified by Leavesley (1996:77) in which two 20,000 bp determinations from 50 cm apart were interpreted as indicative of a period of high deposition in the site. Equally, the determinations are inverted and don't overlap at 2 σ and indicated that reworking probably occurred within this unit. Unit 3 represented 50 cm depth of deposit that was slightly less (90%) of Unit 4. The deposition rate was 16 cm per 1000 ^{14}C years and was three times that of Unit 4 representing a period of increased deposition intensity. The particle size data indicate a reduction in the percentage of sediment <125 μ. The colour changed marginally from HYR 6/2 to H2.5Y 5/2 and the pH levels changed to alternating between 9 and 10.

The radiocarbon data indicated a temporal hiatus of 5000 ^{14}C years (6500 calibrated years) between 17,000 bp and 12,000 bp (19,650 BP to 13,150 BP) and represented the boundary between Unit 2 and Unit 3. There were also changes in sediment colour and pH. The colour altered from H10YR 5/2 to H10YR 4/2 and the pH dropped considerably from 10 to 8.5.

Unit 2 represents 5000 ^{14}C years (4950 calibrated years) between 7000 bp and 12,000 bp (8200 BP to 13,150 BP). The ^{14}C data hinted that three quarters of the deposit may represent the period from 12,000 bp to 10,000 bp with a subsequent reduction in deposition between 10,000 bp and 7000 bp. Future research will determine the extent to which unit 2 might be a palimpsest of two smaller units. While the ^{14}C determinations were in chronological order the presence of pottery in this unit suggested some intermixing with Unit 1 (above). Unit 2 includes 45 cm depth of deposit and had slightly less volume (90%) than Unit 3 with slightly more than half ($9cm^2$/1000 ^{14}C years) the rate of deposition.

Unit 1, the upper most phase, was delineated from Unit 2 based on the ^{14}C data and is coincident with a change in sediment colour. It represents 1700 ^{14}C years between 3500 bp to 1800 bp (3300 BP to 1300 BP). The rate of deposition doubles compared to Unit 2 at 23 cm per 1000 years. The sediment colour alters from H10YR 4/2 to H10YR 4/1.

5. CONCLUSION

The purpose of this chapter was fourfold. First, it described the 1985 excavation method and results for Buang Merabak highlighting the strengths and weaknesses. Secondly, it presented evidence that extended back the temporal timeframe of human occupation of the site to 39,590 bp. Thirdly, it described the additional research undertaken on the site chronology and clarified the hiatuses in occupation and fourthly it describes the units that are utilized in chapters 4 to 8. The units are based on stratigraphic and chronological data collected during excavation. The units have similar characteristics to those utilized elsewhere in New Ireland sites (Leavesley and Allen 1998:80). Buang Merabak was occupied earlier, but not remarkably earlier, than its generally contemporary Bismarck Archipelago sites and is represented by Unit 4. There was evidence of occupation at 20,000 bp (Unit 3) and re-use again immediately prior to the Holocene

(Unit 2). Units 3 and 2 were separated by a depositional hiatus. Unit 2 was followed by another hiatus and re-use during the Late-Holocene (Unit 1). The Units described above are the basis of the following analyses and interpretations.

Chapter 4
Faunal assemblage: Analysis Method and Results

1. INTRODUCTION

This Chapter presents the Buang Merabak archaeological faunal assemblage analysis results. The Chapter begins by describing the methodological approach and is presented in terms of the Units described in Chapter 3 and is quantified in terms of the Number of Individual Specimens Present (NISP) and Minimum Number of Individuals (MNI) for taxa and elements within each Unit. Minimum Number of Individuals per taxa results were calculated by two separate methods and comparisons are made between them in order to investigate their relative accuracy.

An archaeofaunal assemblage can be quantified in a variety of ways. The criteria are number, weight, taxon, body part, element and sub-element (Lyman 1997:102-113). In order to estimate the quantity of animals that a given assemblage represents two calculations are conventionally utilized and they are NISP and MNI. The NISP was calculated to produce a value for the maximum possible number of animals represented by the assemblage while the MNI produces a value representing the lowest possible number of animals represented. The NISP is calculated by summing the number of bone specimens in the assemblage and was utilized at the assemblage and taxa level. The MNI underestimates the total number of animals at a site and provides balance to the NISP, to which it is conventionally compared. NISP and MNI per unit are utilized to investigate the change in the degree of emphasis placed on each taxa over time. The respective calculation methods are described below.

The specimens were differentiated between taxa based on species, genus, family order or class. The specimens were sorted into body part categories including: cranial, axial, girdle or long bones. Where possible, each bone was identified to element following the von den Driesch (1976) and recorded in a Lotus Approach database (Appendix 4). The sub-element categories conventionally divide each element into proximal medial and/or distal portions but in this analysis are identified at a finer scale. Each of the categories reflects a different level of specificity in the data they generate. The broader the categories, the more general the data and vice-versa.

For each specimen, information reflecting the site, test pit, stratigraphic layer, spit and date of excavation was recorded in order to identify each specimen within the excavation and interpretative method. The material from the 1985 excavation was subject to a series of analyses (Leavesley 1996). All mandibles, maxillae and dentary fragments were identified to taxa. The post-cranial specimens were identified to species depending upon the presence of appropriate diagnostic morphological features. Each element was recorded to a third of an element (proximal, medial and distal) to provide a broad description of the assemblage. The 1985 assemblage was not reanalysed for this dissertation because it was collected using a 5 mm sieve mesh and therefore was not comparable with the 2000 excavation material that was collected with a 3 mm sieve mesh. The following analysis was undertaken on material excavated in 2000 only.

1.2 The Assemblage

The Buang Merabak TP1B assemblage contains 28,588 fragments weighing 4822.26 grams at an average of 0.172 grams per specimen (Table 14). The entire bone assemblage was sorted on the basis of taxa (for fish see Appendices 6 and 7) or listed as unidentified. Most were identified primarily by cranial morphology and tooth morphology and secondarily through post-cranial bone morphology. All dentary fragments were viewed under a low-powered microscope to increase clarity and reduce uncertainty. All taxa designations were assigned through close consultation with the appropriate zoologists listed in table 15.

Table 14: NISP (total bone) per unit (TP1B).

Unit	NISP	Sediment wt. (gm.)	Depth (m)	Volume (m^3)	NISP/m^3	NISP per 10,000 years
1	2799	394.3	0.40	0.278	8836	51977
2	9423	529.11	0.45	0.45	19815	39631
3	5791	605.05	0.50	0.50	11424	38080
4	10575	749.60	0.65	0.629	16745	13396
Total	28588	2278.06	2.00	1.858	N/A	N/A

Faunal assemblages consist of disarticulated and commonly highly fragmented specimens giving the appearance of a large quantity of animals. Analyses of NISP, MNI and MNE (Minimum Number of Elements) were designed to quantify the assemblage in terms of the animals and elements represented by the assemblage (Lyman 1997). For this dissertation, only the former two analyses are utilized because the latter is more appropriate in circumstances in which off-site butchering has a major role in the assemblage composition.

Table 15: Zoologists who assisted with taxa identifications.

Taxa	Researcher	Institution	Results
Chiroptera	Sue Hand	UNSW	Appendix 5
Fish	Lyn Schmidt	ANU	Appendix 6
Sharks	Noel Kemp	Tasmanian Museum	Appendix 7
Lizards	Mark Hutchinson	SA Museum	Appendix 8
Snakes	John Scanlon	SA Museum	Appendix 8
Rodentia	Ken Aplin	CSIRO	Appendix 9

The identification of the specimens to taxa was complicated by their incomplete nature and therefore each specimen was considered individually. The most diagnostic bones were the dentary specimens while the diaphyses were the least diagnostic. In order to express the complexity of the data the assemblage was described in terms of both dentary and post-cranial specimens. Fourteen distinct mammals and two reptiles were identified and are listed in table 2.

New Ireland has had a variety of land-based taxa. The fauna consists of 39 mammal taxa including cuscus, a pademelon, bats and rats and a variety of lizards, snakes and birds (Flannery 1995:418). The NISP and MNI analysis below describes which taxon were present in the Buang Merabak TP1B assemblage and in what quantities.

2. NUMBER OF INDIVIDUAL SPECIMENS PRESENT (NISP)

Tables 16 to 23 list the NISP and weight of both dentary and post-cranial fragments per taxa in Units 1 to 4 and are summarised in tables 24 and 25. Dentary specimens are either teeth, or teeth and jawbones. The dentary category includes elements containing teeth, such as mandibles, maxillae and premaxillae and are listed in tables 16, 17, 20 and 22 and are summarized in table 12. The tables also indicate which taxa are known to inhabit cave environments. The taxa that utilize both cave and bush environments are listed under the 'Habitat' category as 'cave/bush'.

Tables 16 and 17 list the results of the analyses of the Unit 1 faunal assemblage. They indicate that the *P. orientalis* was the most common taxon by both NISP and weight while Lizards, Reptilia and *Pteropus* sp. were the least prevalent. By weight, *P. orientalis* made up 81.78% of the identified cranial bone and 96.93% of the post-cranial bone. By NISP it made up 67.17% identified cranial bone and 89.83% of the post-cranial bone.

Table 16: NISP and weight of dentary specimens per taxa per Unit 1. *Dobsonia* includes specimens that are indistinguishable between *D. anderseni* and *D. praedatrix*. Megapteroptera does not include specimens already recorded to species but does include unidentifiable specimens from either *Pteropus* or *Dobsonia* families.

Taxa	**NISP**	**NISP %**	**Wt.**	**Wt. %**	**Habitat**
P. orientalis	42	89.36	32.93	96.93	Bush
D. anderseni	0	0	0	0	Cave
D. praedatrix	0	0	0	0	Cave
Dobsonia sp.	4	8.51	0.41	1.21	Cave
Pteropus sp.	0	0	0	0	Bush
Megapteroptera	1	2.12	0.7	2.05	Bush/cave
Lizard	0	0	0	0	Bush
Total	47	100	34.04	100	

The Megapteroptera contributed most of the remaining identified bone with 28.72% (plus 0.21% identified specifically to *Pteropus* sp.) of post-cranial NISP but only 10.63% of dentary specimens and 13.89% of post-cranial weight and 3.25% of identified dentary specimens. The disparity between the percentages of post-cranial to cranial bones across the taxa is a reflection of the different sizes and therefore weight of the *P. orientalis* being on average 8 times the body size of the *Dobsonia* species. Therefore, the NISP values present the best comparison of quantity because the results are not skewed by the different average weight of the taxa.

Table 17: NISP and weight of post-cranial specimens per taxa in Unit 1. *Dobsonia* sp. includes specimens that are indistinguishable between *D. anderseni* and *D. praedatrix*. Megapteroptera includes unidentifiable specimens from either *Pteropus* or *Dobsonia* families. The reptile category includes lizard and snake axial elements.

Taxa	**NISP**	**NISP %**	**Wt.**	**Wt. %**	**Habitat**
P. orientalis	311	66.88	150.85	81.78	Bush
T. browni	10	2.15	7.60	4.12	Bush
Pteropus	1	0.21	0.09	0.04	Bush
Megapteroptera	133	28.61	24.89	13.49	Cave/bush
Lizard	0	0	0	0	Bush
Reptilia	8	1.72	1.01	0.54	Bush
Rodentia	2	0.43	N/A	N/A	Bush
Total	465	100.00	184.44	100.00	

The results in tables 18 and 19 indicate a similarly high proportion of *P. orientalis* in Unit 2 as occurred in Unit 1. The NISP values for *P. orientalis* are 85.57% of identified dentary specimens and 81.97% of identified post-cranials specimens compared to the combined total of Megapteroptera taxonomic categories (including *Pteropus* sp., *Dobsonia* sp., *D. anderseni*, and *D. praedatrix*) that are 14.09% of dentary and 16.72% of identified post-cranial specimens. Considering the results from tables 16 to 19, the *P. orientalis* was the predominant taxon in Units 1 and 2.

The results in tables 20 and 21 representing Unit 3 are remarkably different to the results in tables 16 to 19. By identified dentary specimens the most prevalent taxonomic category was *D. anderseni* represented by 43.72% of the NISP followed by unidentified *Dobsonia* sp. at 25%. The *Dobsonia* sp. category was relatively high because the Dobsonia sp. specimens exhibited a degree of post-mortem tooth eruption that made the distinction between *D. anderseni* and *D. praedatrix* unreliable. The post-cranial category was dominated by Megapteroptera specimens (91.51% of the NISP for Unit 3). The post-cranial Megapteroptera included specimens from either *Dobsonia* sp., small *Pteropus* sp. or large *Rousettus* sp. individuals because their relatively homogenous post-cranial skeletal morphology made the distinction between taxa unreliable. Therefore, the results indicate that in Unit 3 *Dobsonia* sp. were the most dominant taxa by dentary specimens and Megapteroptera were the most prevalent by post-cranial specimens.

Table 18: NISP and weight of dentary specimens per taxa per Unit 2. *Dobsonia* sp. includes specimens that are indistinguishable between *D. anderseni* and *D. praedatrix*. Megapteroptera does not include specimens already recorded to species but does include unidentifiable specimens from either *Pteropus* or *Dobsonia* families.

Taxa	**NISP**	**NISP %**	**Wt.**	**Wt. %**	**Habitat**
P. orientalis	273	85.04	212.48	95.29	Bush
D. anderseni	18	5.61	4.84	2.17	Cave
D. praedatrix	1	0.31	0.30	013	Cave
Dobsonia sp.	19	5.91	4.20	1.88	Cave
Pteropus sp.	3	0.93	0.50	0.22	Bush
Megapteroptera	4	1.24	0.56	0.25	Bush/cave
Lizard	1	0.31	0.09	0.04	Bush
Rodentia	2	0.62	N/A	N/A	Bush
Total	321	100	222.97	100	

Table 19: NISP and weight of post-cranial specimens per taxa in Unit 2. *Dobsonia* sp. includes specimens that are indistinguishable between *D. anderseni* and *D. praedatrix*. Megapteroptera includes unidentifiable specimens from either *Pteropus* or *Dobsonia* families. The reptile category includes lizard and snake axial elements.

Taxa	**NISP**	**NISP %**	**Wt.**	**Wt. %**	**Habitat**
P. orientalis	1646	81.97	1000.8	92.53	Bush
T. browni	9	0.44	6.2	0.57	Bush
Pteropus sp.	2	0.09	1.55	0.14	Bush
Megapteroptera	334	16.63	69.04	6.38	Cave/bush
Lizard	3	0.14	0.59	0.05	Bush
Reptilia	14	0.69	3.37	0.31	Bush
Total	2008	100	1081.55	100	

Table 20: NISP and weight of dentary specimens per taxa in Unit 3. *Dobsonia* sp. includes specimens that are indistinguishable between *D. anderseni* and *D. praedatrix*. Megapteroptera does not include specimens already recorded to species but does include unidentifiable specimens from either *Pteropus* or *Dobsonia* families.

Taxa	**NISP**	**NISP %**	**Wt.**	**Wt. %**	**Habitat**
P. orientalis	9	14.28	23.09	66.29	Bush
T. browni	0	0	0	0	Bush
D. anderseni	21	33.33	6.49	18.63	Cave
D. praedatrix	0	0	0	0	Cave
Dobsonia sp.	12	19.04	4.66	13.37	Cave
Pteropus sp.	0	0	0	0	Bush
Megapteroptera	4	6.34	0.49	1.4	Bush/cave
Lizard	2	3.17	0.1	0.28	Bush
Rodentia	15	23.80	N/A	N/A	Bush
Total	63	100.00	34.83	100.00	

The results in tables 22 and 23 indicate a similarly high proportion of *D. anderseni* in Unit 4 as occurred in Unit 3. The NISP values for *D. anderseni* were 56% of identified dentary specimens and Megapteroptera were 90.26% of identified post-cranials specimens. The results in tables 16 to 19 indicate that the *D. anderseni* was the predominant taxon in Units 3 and 4.

Of the *P. orientalis* specimens listed in table 24 the dentary specimen in Unit 4 was an individual upper molar measuring (height) 5.3 mm x (length) 4.9 mm x (width) 4.8 mm. The quantity of specimens per Unit provides an indication of potential for post-depositional disturbance. A high quantity of specimens within a Unit suggests they are in situ while a low quantity suggests the possibility of vertical re-distribution. The relatively small dimensions lend weight to the suggestion that the bone moved down in the sediment profile from Unit 3. The specimen is recorded in spit 31 suggesting downward movement in the order of 15 cm.

Table 21: NISP and weight of post-cranial specimens per taxa in Unit 3. *Dobsonia* sp. includes specimens are indistinguishable between *D. anderseni* and *D. praedatrix*. Megapteroptera includes unidentifiable specimens from either *Pteropus* or *Dobsonia* families. The reptile category includes lizard and snake axial elements.

Taxa	**NISP**	**NISP %**	**Wt.**	**Wt. %**	**Habitat**
P. orientalis	32	2.24	36.29	12.65	Bush
T. browni	1	0.07	1.3	0.45	Bush
Pteropus sp.	5	0.35	7.1	2.47	Cave
Megapteroptera	1300	91.16	210.5	73.42	Cave/bush
Lizard	34	2.38	6.4	2.23	Bush
Reptilia	54	3.78	25.11	8.75	Bush
Total	1426	100	286.7	100	

Table 22: NISP and weight of dentary specimens per taxa in Unit 4. *Dobsonia* sp. includes specimens that are indistinguishable between *D. anderseni* and *D. praedatrix*. Megapteroptera does not include specimens already recorded to species but does include unidentifiable specimens from either *Pteropus* or *Dobsonia* families.

Taxa	**NISP**	**NISP %**	**Wt.**	**Wt. %**	**Habitat**
P. orientalis	5	3.73	0.04	0.11	Bush
D. anderseni	35	26.11	9.25	27.23	Cave
D. praedatrix	5	3.73	1.3	3.82	Cave
Dobsonia sp.	70	52.23	18.87	55.56	Cave
Pteropus sp.	3	2.23	2.25	6.62	Bush
Megapteroptera	10	7.46	1.95	5.74	Bush/cave
Lizard	1	0.74	0.3	0.88	Bush
Rodentia	5	3.73	N/A	N/A	Bush
Total	134	100.00	33.96	100.00	

Table 24 indicates that the dominant taxa, in TP1B, were *P. orientalis* and the *Dobsonia* species. The *Dobsonia* sp. dominates Units 3 and 4 while *P. orientalis* dominates Units 1 and 2 and mirrors a pattern previously suggested for the site (Leavesley and Allen 1998). Other taxa such as the families Reptilia and Rodentia play an important but smaller role in the assemblage. The post-cranial elements were from body part categories including: axial, girdle, axial and long bones.

Table 23: NISP and weight of post-cranial specimens per taxa in Unit 4. *Dobsonia* sp. includes specimens that are indistinguishable between *D. anderseni* and *D. praedatrix*. Megapteroptera includes unidentifiable specimens from either small *Pteropus* or *Dobsonia* families. The reptile category includes lizard and snake axial elements.

Taxa	**NISP**	**NISP %**	**Wt.**	**Wt. %**	**Habitat**
P. orientalis	0	0	0	0	Bush
T. browni	0	0	0	0	Bush
Pteropus sp.	73	2.75	59.6	9.82	Bush
Megapteroptera	2391	90.26	435.99	71.84	Cave/bush
Lizard	77	2.91	43.34	7.14	Bush
Reptilia	108	4.07	67.91	11.19	Bush
Total	2649	100	606.84	100	

Table 24: NISP and weight of dentary specimens per taxa per unit. *Dobsonia* includes both *D. anderseni* and *D. praedatrix*. Megapteroptera does not include specimens already recorded to species but does include unidentifiable specimens from either of the families: *Pteropus* sp. or *Dobsonia* species.

Taxa	**Unit 1**		**Unit 2**		**Unit 3**		**Unit 4**	
	NISP	**Wt.**	**NISP**	**Wt.**	**NISP**	**Wt.**	**NISP**	**Wt.**
P. orientalis	42	32.93	273	212.48	9	23.09	1	0.04
D. anderseni	0	0	18	4.84	21	6.49	35	9.25
D. praedatrix	0	0	1	0.3	0	0	5	1.3
Dobsonia sp.	4	0.41	19	4.2	12	4.66	70	18.87
Pteropus sp.	0	0	3	0.5	0	0	3	2.25
Megapteroptera	1	0.7	4	0.56	4	0.49	10	1.95
Lizard	0	0	1	0.09	2	0.1	1	0.3

The *T. browni* specimen in Unit 3 (see table 25) was a metatarsal element recorded from spit 18. Macropod metatarsal elements are highly distinctive and therefore diagnostic. *T. browni* has not been identified in pre-Last Glacial Maximum deposits at any other New Ireland sites (Allen et al. 1989) and nor is it identified at pre-Last Glacial Maximum levels by previous analyses of Buang Merabak (Leavesley 1996; Leavesley and Allen 1998). At first glance the presence of an isolated bone further down the sequence than expected might be interpreted as consistent with post-depositional downward movement or disturbance. However, given that the bottom of Unit 2 is spit 17 and the top of Unit 3 (as defined in Chapter 3) is spit 18 the presence of the element may indicate the division between the units that does not precisely match the division between the spits and consequently the bone may be interpreted as *in situ* but associated with Unit 2 rather than Unit 3.

Table 25: NISP and weight of post-cranial specimens per taxa per analytical unit. *Dobsonia* sp. includes specimens that are indistinguishable between *D. anderseni* and *D. praedatrix*. Megapteroptera includes unidentifiable specimens from either *Pteropus* or *Dobsonia* families. The reptile category includes lizard and snake axial elements.

Taxa	**Unit 1**		**Unit 2**		**Unit 3**		**Unit 4**	
	NISP	**Wt.**	**NISP**	**Wt.**	**NISP**	**Wt.**	**NISP**	**Wt.**
P. orientalis	311	150.85	1646	1000.8	32	36.29	0	0
T. browni	10	7.6	9	6.2	1	1.3	0	0
Pteropus sp.	1	0.09	2	1.55	5	7.1	73	59.6
Megapteroptera	133	24.89	334	69.04	1300	210.5	2391	435.99
Lizard	0	0	3	0.59	34	6.4	77	43.34
Reptilia	8	1.01	14	3.37	54	25.11	108	67.91
Rodentia	2	N/A	2	N/A	15	N/A	5	N/A

2.2 Comparison of Thylogale browni and Phalanger orientalis NISP

Table 26 compares the NISP and weight of the *P. orientalis* and *T. browni* per unit. While neither taxon occurred in Unit 4 the former peaked in Unit 2 and the later in both Units 1 and 2. *P. orientalis* relative to *T. browni* are present at a ratio of 99.5:1 by post-cranial NISP and 78.7:1 by post-cranial weight. For the purposes of this calculation the NISP value is considered a better representation of quantity because the low quantity of *T. browni* specimens would artificially inflate an MNI calculation.

Table 26: *Thylogale browni* and *Phalanger orientalis* post-cranial NISP and weight in grams per unit.

Taxa	**Unit 1**		**Unit 2**		**Unit 3**		**Unit 4**	
	NISP	Wt.	NISP	Wt.	NISP	Wt.	NISP	Wt.
T. browni	10	7.6	9	6.2	1	1.3	0	0
P. orientalis	311	150.85	1646	1000.8	32	36.29	0	0

2.3 Chiroptera

Chiroptera includes Megapteroptera and Micropteroptera. Table 27 lists the NISP and weight of Micropteroptera bones per unit for TP1B. The assemblage contains a total of 5881 (20% of total

NISP) specimens of Micropteroptera bone weighing a total of 195.69 gms at an average weight of 0.03 gms per specimen.

Table 27: NISP and weight (gm.) of selected small taxa from TP1B.

Taxa	**Unit 1**		**Unit 2**		**Unit 3**		**Unit 4**	
	NISP	Wt.	NISP	Wt.	NISP	Wt.	NISP	Wt.
Micropteroptera	129	5.68	700	41.98	1916	19.09	3136	128.94

The table 25 *P. orientalis* evidence suggests a depositional change between Units 4 and 3. In order to determine whether the change was taxon specific *Dobsonia* sp. data are presented in table 28 as percentage of each element/body part per unit.

Table 25 indicates that for the site overall *P. orientalis* was the dominant taxon by NISP and weight followed by the Megapteroptera. *P. orientalis* was present in Unit 3 and became dominant in Unit 2 and Unit 1. The Megapteroptera were dominant in Units 4 and 3. In Unit 2 Megapteroptera make up a small proportion of the assemblage. The family Reptilia and lizards played a smaller role but make their greatest contribution in Unit 4 and drop-off by NISP in the later units. *T. browni* was present in Units 1 and 2 but only in low quantities. NISP results can be influenced by fragmentation.

Table 28: The percentage of *Dobsonia* sp. element/body part per unit for TP1B.

Element/body part	**Unit 3**	**Unit 4**	**Ratio**
Mandible	25.6	12.54	2.04:1
Humerus	14.63	8.24	1.77:1
Ulna	37.8	44.08	1:0.86
Femur	15.85	3.22	4.9:1
Tibia	10.97	10.03	1.09:1
Axial	10.97	21.86	0.5:1

The NISP value is limited by its relationship to fragmentation. The greater the fragmentation, the smaller the fragments and the larger the NISP value. Therefore, quantification of the assemblage requires the calculation of both the maximum and minimum possible number of animals that contributed to the assemblage. The NISP value represents the maximum but does not provide the minimum that is therefore the topic of the next section.

3. MINIMUM NUMBER OF INDIVIDUALS (MNI)

MNI represents the minimum number of animals required to account for the bone assemblage. The MNI is calculated by counting the number of specimens per taxon per unit and assigning them to symmetry. The element with the largest value is divided by symmetry and the larger of the symmetry values is taken as representative of the population. In this analysis the MNI is calculated using two different base units: the element (anatomically complete bone or tooth) and the sub-element (discrete part of an element). They are expressed in this fashion in order to determine the accuracy of the former relative to the latter. Table 29 lists the number of specimens per Unit for *P. orientalis* to indicate the general distribution of body parts and elements over time. Table 30 presents the MNI as calculated using the element as the base unit while tables 31, 32, 33, 34, 35, 36 and 37 present data reflecting the use of the sub-element as the base unit. They are followed by similar data for Chiroptera, Megapteroptera, *Dobsonia anderseni, D. praedatrix*, *Pteropus* sp. and the class Reptilia.

3.2 Phalanger orientalis MNI

The number of elements per taxa provides the minimum number of individual animals deposited at the site. Table 29 lists the number of elements per unit for the *P. orientalis*.

Table 29: Number of *Phalanger orientalis* elements per unit in TP1B.

Element	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**
Group I				
Rib	24	191	0	0
Vertebra	15	137	0	0
Sacrum	0	0	0	0
Sternum	1	3	0	0
Groups I & II				
Scapula	3	22	1	0
Phalange	1	0	0	0
Ulna	38	134	7	0

Table 30: Number of (selected) elements per unit per symmetry for *Phalanger orientalis* in TP1B. N/A reflects the number of specimens identified to element but did not exhibit morphological features indicative of symmetry.

Elements	**Unit 1**			**Unit 2**			**Unit 3**		
	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A
Mandible	15	24	1	107	85	6	2	4	0
Humerus	18	28	2	117	97	12	5	0	0
Radius	5	6	11	34	36	67	0	0	1
Ulna	18	14	6	56	74	4	2	4	1
Femur	12	12	23	81	83	76	4	5	2
Tibia	0	1	17	5	1	190	1	0	4
Fibula	11	6	7	34	27	34	0	0	0
Element MNI	18	28	12	117	97	95	5	5	4

Table 31: Number of tibia sub-element recorded for *Phalanger orientalis* per unit in TP1B.

Tibia sub-elements	**Unit 1**			**Unit 2**			**Unit 3**		
	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A
Proximal epyphysis	0	0	1	0	1	1	0	0	0
Tibial tuberosity	0	1	2	2	1	36	0	0	0
Interosseus margin	0	1	2	1	1	45	0	0	0
Proximal diaphysis	0	1	7	4	1	95	0	0	0
Mid diaphysis	0	0	15	4	0	142	0	0	3
Distal diaphysis	0	0	12	5	0	102	1	0	4
Fibula notch	0	0	2	1	0	26	1	0	0
Medial malleolus	0	0	3	0	0	0	1	0	0
Sub-element tibia MNI	0	1	8	5	1	71	1	0	2

Table 30 lists the number of *P.orientalis* specimens to element and symmetry. If the element did not exhibit morphological features indicative of symmetry it was listed as 'N/A'. Unit 4 does not contain any *P. orientalis* specimens and is therefore absent from table 30. The data in Table 30 indicate that Unit 2 contains the largest number of *P. orientalis* specimens followed by Unit 1 and then Unit 3. Utilising the element for MNI calculations in conjunction with the total per symmetry category produces an MNI value of 28 for Unit 1, 117 for Unit 2 and 5 for Unit 3. The humeri data for Unit 2 indicate an MNI of 117 reflected by the 'left' symmetry category. The relatively large disparity between the NISP for tibia and humeri is unusual because live animals have the same number of both. In order to explore the apparent disparity between the tibia and humerus NISP values the sub-element data are presented in Tables 31 and 32. Each element was divided into a series of sub-element categories based on their specific morphological traits. For example, the tibia was divided into eight sub-elements (Proximal epyphysis, tibial tuberosity, interosseus margin, proximal diaphysis, mid-diaphysis, distal diaphysis, fibula notch and medial malleolus). For each tibia specimen the presence or absence of each sub-element was recorded in a Lotus Approach database.

The commonest tibia sub-element present in Unit 1 and 2 is the mid diaphysis numbering 8 and 71 specimens respectively (table 31). In Unit 3 the commonest sub-element is the distal diaphysis numbering two. The high proportion of sub-elements in the unknown symmetry category reflects the relatively homogenous morphology of the tibia diaphysis. This probably represents a high level of fragmentation of the *P. orientalis* tibia.

Table 32: Number of humerus sub-element recorded for *Phalanger orientalis* per unit in TP1B.

Humerus sub-element	**Unit 1**			**Unit 2**			**Unit 3**		
	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A
Humerus head	0	3	1	21	23	1	0	0	0
Anatomical neck	1	3	1	22	23	1	0	0	0
Greater tuberosity	0	1	0	22	22	1	0	0	0
Lesser tuberosity	1	1	0	22	22	0	0	0	0
Surgical neck	4	10	0	46	41	7	0	1	0
Proximal diaphysis	5	12	1	52	51	6	0	2	0
Greater tuberosity crest	10	18	0	79	66	3	0	2	0
Mid diaphysis	9	15	1	74	62	8	0	2	0
Distal diaphysis	9	16	0	76	62	8	0	3	0
Humerus foramen	10	12	0	43	33	0	0	0	3
Sub-element humeri MNI	10	18	1	79	66	4	0	3	2

A comparison between the unknown (N/A) categories in tables 33 and 34 indicates that the humeri, represented in table 32, were more readily identified to symmetry than the tibia (table 31) and potentially reflects the humeri's distinctive morphology. The humeri sub-element data indicate that Unit 1 has an MNI of 18, Unit 2 equals 79 and Unit 3 equals 3. A comparison between the humeri data in tables 28 and 29 indicates that the utilisation of the element categories, relative to the sub-element categories, over estimates the MNI value. A comparison of the tibia and humeri sub-element MNI values indicate that they are a lot closer than the element MNI values and demonstrates that the sub-element data is a more accurate tool for the calculation of MNI values. The sub-element distribution analysis provides data to investigate the relative intensity of reduction in the breakage of each specific element.

Table 33: Number of femur sub-element recorded for *Phalanger orientalis* per unit in TP1B.

Femur sub-element	**Unit 1**			**Unit 2**			**Unit 3**		
	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A
Femur head	3	2	0	15	29	1	0	0	0
Femur neck	3	2	0	22	31	1	0	0	0
Greater trochanter	4	3	0	42	48	1	3	2	0
Lesser trochanter	5	3	0	43	52	2	3	2	0
Proximal diaphysis	5	3	16	46	51	2	4	2	0
Mid diaphysis	7	3	20	39	32	59	4	0	1
Distal diaphysis	8	5	18	38	39	58	4	3	2
Popliteal surface	7	7	4	35	32	31	2	3	1
Medial epicondyle	1	3	1	26	29	6	1	3	1
Lateral epicondyle	3	6	0	26	29	6	1	3	1
Medial condyle	3	4	0	5	7	1	0	0	1
Lateral condyle	3	5	0	9	12	2	0	1	1
Sub-element femur MNI	8	7	10	46	52	29	4	3	1

Table 34: Number of mandible sub-element specimens recorded for *Phalanger orientalis* per unit in TP1B.

Mandible sub-element	**Unit 1**			**Unit 2**			**Unit 3**		
	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A
Mental protuberance	1	3	0	25	11	0	2	2	0
Mental spine	0	1	0	1	1	0	0	0	0
Symphysis	4	8	0	40	31	0	2	2	0
Mental foramen	4	7	0	41	32	0	2	2	0
Anterior ramus of dentary	4	10	0	63	42	0	2	2	0
Posterior ramus of dentary	10	19	1	67	58	7	2	4	0
Vertical ramus	7	11	0	47	34	0	1	3	0
Angular process	4	3	0	18	15	0	1	2	0
Condyle	2	1	0	13	5	0	0	1	0
Coronoid process	0	0	0	0	0	0	0	0	0
Sub-element mandible MNI	10	19	1	67	58	4	2	4	0

Utilising data collected at the sub-element level provides finer resolution results because the element MNI does not record every sub-element as equal to an element. For example, if there are three fibula specimens, one includes the fibula head and proximal diaphysis, the second is a fibula Head and the third a proximal diaphysis. The MNI method of identification to either proximal medial or distal fibula would count the specimens as equalling 3 fibulae while the sub-element method would count the specimens as equalling 2 fibulae. A comparison of the element results in table 30 and the sub-element results in table 38 indicates the extent to which the sub-element MNI value differs from the element MNI values for the same *P. orientalis* assemblage. The MNI for *P. orientalis*, using the sub-element method in Unit 1, equals 19 down from 28, Unit 2 equals 79, down from 117 and Unit 3 equals 4 down from 5 (see table 38). For Unit 1 the MNI value was revised by 35% and Unit 2 by 32% and indicates that there is a substantial difference between the two methods of calculating MNI.

Table 35: Number of radius sub-elements recorded for *Phalanger orientalis* per unit in TP1B.

Radius sub-element	**Unit 1**			**Unit 2**			**Unit 3**		
	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A
Radius head	0	1	6	14	17	41	0	0	1
Radial tuberosity	1	2	8	17	18	58	0	0	1
Proximal diaphysis	5	3	8	25	25	64	0	0	1
Mid diaphysis	4	5	3	25	28	16	0	0	1
Distal diaphysis	2	4	0	17	14	2	0	0	0
Ulnar notch	0	0	0	0	2	0	0	0	0
Carpal articular surface	0	0	0	0	2	0	0	0	0
Sub-element radius MNI	5	5	4	25	28	32	0	0	1

Table 36: Number of ulna sub-element recorded for *Phalanger orientalis* per unit in TP1B.

Ulna sub-element	**Unit 1**			**Unit 2**			**Unit 3**		
	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A
Ulna head	15	7	0	42	40	0	0	2	0
Olecranon process	15	11	0	48	45	1	0	4	0
Trochlear notch	16	13	0	51	50	1	0	4	0
Coronoid process	15	13	0	52	53	1	1	4	0
Radial notch	18	13	0	55	60	1	2	4	0
Proximal diaphysis	14	8	6	43	56	3	2	3	0
Mid diaphysis	1	4	6	19	25	3	1	1	1
Distal diaphysis	0	0	6	4	15	3	0	0	0
Articular circumference	0	0	0	0	0	0	0	0	0
Styloid process	0	0	0	0	0	0	0	0	0
Sub-element ulna MNI	18	13	3	55	60	2	2	4	1

Table 37: Number of fibula sub-elements recorded for *Phalanger orientalis* per unit in TP1B.

Fibula sub-element	**Unit 1**			**Unit 2**			**Unit 3**		
	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A
Proximal epyphysis	0	0	0	4	2	0	0	0	0
Fibula head	11	6	4	31	25	13	0	0	0
Proximal diaphysis	11	6	5	32	24	15	0	0	0
Mid diaphysis	8	3	5	15	14	25	0	0	0
Distal diaphysis	0	1	4	3	2	21	0	0	0
Fibula distal surface	0	0	4	2	2	20	0	0	0
Fibula distal epyphysis	0	0	0	1	0	4	0	0	0
Minimum number of fibula	11	6	3	32	25	25	0	0	0

Table 38: Summary of *P. orientalis* element MNIs, using the sub-element data from tables 29 to 37.

Elements	**Unit 1**			**Unit 2**			**Unit 3**		
	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A
Mandible	10	19	1	67	58	4	2	4	0
Humeri	10	18	1	79	66	4	0	3	2
Radius	5	5	4	25	28	32	0	0	1
Ulna	18	13	3	55	60	2	2	4	1
Femur	8	7	10	46	52	29	4	3	1
Tibia	0	1	8	5	1	71	1	0	2
Fibula	11	6	3	32	25	25	0	0	0
Sub-elements MNI	**18**	**19**	**8**	**79**	**66**	**71**	**2**	**4**	**2**

3.2.2 Phalanger orientalis NISP and MNI Results-Summary

The results presented in table 38 are a summary and extrapolation of the *P. orientalis* data presented above. While the actual number of *P. orientalis* in the assemblage is impossible to determine, the NISP and MNI values indicate the upper and lower limits reflecting a range that is likely to contain the true number.

The data in table 39 indicate that the quantity of *P. orientalis* changed over time from absent in Unit 4, to a NISP of 32 and MNI of 4, peaked in Unit 3 with a NISP of 1646 and MNI of 79 in Unit 2 and back down to a NISP 311 and an MNI of 19 in Unit 1. The basic trend remains the same after the data are corrected for years and volume.

Table 39: Number of *P. orientalis* specimens per unit.

	Unit 1	**Unit 2**	**Unit 3**	**Unit 4**
NISP	311	1646	32	0
NISP per m^3	777.5	3567.7	64	0
NISP per 1000 years	182.94	329.2	10.66	0
MNI	19	79	4	0
MNI per m^3	47.5	175.55	8	0
MNI per 1000 years	11.17	15.8	1.3	0

3.3 Megapteroptera MNI

Table 28 represents the post-cranial elements of three species *Dobsonia anderseni*, *D. praedatrix*, *Rousettus amplexicaudatus* and juvenile *Pteropus* species. All four Megapteroptera are included in the same category because their post-cranial elements are morphologically very similar and individuals can overlap in size, making disarticulated specimens more confidently allocated to family than genus or species. Table 40 indicates that relatively few long bones were sufficiently diagnostic to attribute symmetry. Therefore, while it is possible to produce an MNI value it has not been presented because there is not enough classificatory resolution to support a meaningful estimate.

Table 40: Number of Megapteroptera (*Dobsonia anderseni*, *D. praedatrix* or *Rousettus amplexicaudatus*) specimens per category per unit in TP1B.

Elements	**Unit 1**			**Unit 2**			**Unit 3**			**Unit 4**		
	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A
Mandible	0	0	0	1	0	2	1	1	3	3	1	3
Humerus	0	3	1	2	3	8	7	4	1	6	6	11
Radius	1	1	0	1	0	2	0	0	0	0	0	0
Ulna	0	0	0	2	0	2	10	3	18	8	7	108
Femur	0	0	1	0	0	0	0	0	13	0	0	9
Tibia	0	0	2	0	0	5	0	0	9	0	0	28
Fibula	0	0	0	0	0	0	0	0	0	0	0	0
Long bones (unknown)			62			226			1052			2127
MNI	1	3	1	2	3	8	10	4	9	8	7	54

The large quantity of long bones per unit also reflects the homogenous and therefore un-diagnostic nature of the Megapteroptera diaphyses. In order to determine an MNI value other elements, particularly the mandibles, are more instructive and are presented per taxa rather than family in tables 41 to 43.

3.4 Dobsonia anderseni MNI

The data in table 29 follow a similar downward trend from Unit 4 to Unit 1. The MNI in Unit 4 equals 19, Unit 3 equals 13, Unit 2 equals 13 and Unit 1 equals 0. Table 30 lists the presence of the sub-element parts of the *D. anderseni* mandible.

Table 41: Number of *Dobsonia anderseni* mandible sub-elements per symmetry for TP1B.

Mandible sub-elements	**Unit 1**			**Unit 2**			**Unit 3**			**Unit 4**		
	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A	Left	Right	N/A
Mental protuberance	0	0	0	6	3	0	11	2	0	3	8	0
Mental spine	0	0	0	3	2	0	1	0	0	0	3	0
Symphysis	0	0	0	8	3	0	12	4	0	5	9	0
Mental foramen	0	0	0	13	5	0	12	7	0	14	16	0
Anterior ramus of dentary	0	0	0	13	5	0	13	8	0	16	19	0
Posterior ramus of dentary	0	0	0	7	4	0	6	5	0	12	11	0
Vertical ramus	0	0	0	4	0	0	4	3	0	6	5	0
Angular process	0	0	0	0	0	0	0	1	0	1	5	0
Condyle	0	0	0	0	0	0	0	0	0	0	0	0
Coronoid process	0	0	0	0	0	0	0	1	0	0	0	0
MNI	0	0	0	13	5	0	13	8	0	14	19	0

Results in table 42 indicate a similar distribution of sub-elements within the *D. anderseni* mandible between Units 3 and 4. A chi square test of the sub-elements (excluding: the mental spine, angular process, condyle and coronoid process because of their low values) suggest they are not significantly different. For significance at the 0.05 level, chi-square should be greater than, or equal to 11.07. Chi-square is 5.06 ($p \leq 1$), therefore the values are not significantly different. The corrected data however, tell a different story. It is not subject to a chi square on the grounds that the Unit 4 values are not great enough to be statistically meaningful. Unit 3 contained 3.5:1 more mandibles per 1000 years/m^3 than Unit 4. Additionally, there is a distinction between an emphasis on the presence of sub-elements of the posterior ramus of dentary in Unit 4 as opposed to an emphasis on the symphysis and mental protuberance in Unit 3.

The data in table 43 reflect all the Megapteroptera ulna specimens because apart from size, it is very difficult to differentiate between taxa on morphology grounds due to the lack of diagnostic attributes. Nevertheless, the average ratio for the mandibles by sub-element per 1000 years/m^3 is 1.5:1 in favour of Unit 3.

Table 42: Number of *Dobsonia anderseni* mandible sub-elements and percentage per unit in TP1B. 'Crected' is results adjusted for time (per 1000) and volume (m^3) see table 13 and the ratio reflects the corrected data.

Mandible sub-elements	**Unit 3**	**Unit 3 %**	**Crected**	**Unit 4**	**Unit 4 %**	**Crected**	**Ratio**
Mental protuberance	13	14.44	8.66	11	8.1	1.35	6.5:1
Mental spine	1	1.11	0.66	3	2.4	0.36	1.8:1
Symphysis	16	17.77	10.66	14	10.6	1.72	6.2:1
Mental foramen	19	21.12	12.66	30	22.65	3.69	3.4:1
Anterior ramus of dentary	21	23.33	14	35	26.4	4.31	3.2:1
Posterior ramus of dentary	11	12.22	7.3	23	17.4	2.83	2.6:1
Vertical ramus	7	7.77	4.66	11	8.12	1.35	3.5:1
Angular process	1	1.12	0.66	6	4.61	0.78	0.85:1
Condyle	0	0	0	0	0	0	N/A
Coronoid process	1	1.12	0.66	0	0	0	N/A
Total	90	100	59.92	133	100	16.39	3.65:1

Table 43: Megapteroptera ulna sub-element NISP and percentage per unit in TP1B. 'Crectd' results are adjusted for unit time (per 1000) and volume (m^3) from table 13 and the ratio reflects the corrected data.

Ulna sub-elements	**Unit 3**	**Unit 3 %**	**Crected**	**Unit 4**	**Unit 4 %**	**Crected**	**Ratio**
Ulna head	10	12.82	6.66	50	16.89	6.15	1:1.08
Radial notch	0	0	0	4	1.35	0.49	N/A
Proximal diaphysis	8	10.25	5.33	46	15.54	5.66	0.94:1
Mid diaphysis	2	2.56	1.33	6	2.02	0.78	1.71:1
Distal diaphysis	22	28.22	14.66	72	24.32	8.86	1.65:1
Articular circumference	21	26.92	14	73	24.66	8.98	1.55:1
Styloid process	15	19.23	10	45	15.22	5.53	1.88:1
Total	78	100	51.98	296	100	36.35	1.42:1

3.5 Dobsonia praedatrix MNI

The data in table 44 suggest that very few specimens were identified explicitly to *D. praedatrix*. The low values preclude any correction of the data for years and volume. Assuming that the *D. praedatrix* data were representative of their contribution to the unidentified long bones presented in table 38, they suggest that while the taxon is clearly present in the assemblage its overall contribution to the human diet was probably low.

Table 44: *Dobsonia praedatrix* mandible sub-element categories to symmetry (L=left; R= right) for TP1B.

Mandible sub-elements	**Unit 1**			**Unit 2**			**Unit 3**			**Unit 4**		
	L	R	N/A	L	R	N/A	L	R	N/A	L	R	N/A
Mental protuberance	0	0	0	0	0	0	0	0	0	2	0	0
Mental spine	0	0	0	0	0	0	0	0	0	0	0	0
Symphysis	0	0	0	0	0	0	0	0	0	1	0	0
Mental foramen	0	0	0	0	0	0	0	0	0	2	1	0
Anterior ramus of dentary	0	0	0	0	0	0	0	0	0	2	1	0
Posterior ramus of dentary	0	0	0	1	0	0	0	0	0	0	3	0
Vertical ramus	0	0	0	1	0	0	0	0	0	0	2	0
Angular process	0	0	0	0	0	0	0	0	0	0	0	0
Condyle	0	0	0	0	0	0	0	0	0	0	0	0
Coronoid process	0	0	0	0	0	0	0	0	0	0	0	0
MNI				1						2	3	

3.6 Pteropus MNI

The data in table 45 indicate that *Pteropus* sp. were present in very low numbers compared to *P. orientalis* and the Megapteroptera (see table 24) and thus make up a very small proportion of the assemblage. Unit 4 contains 90% of all *Pteropus* sp. specimens of which a high proportion were unidentifiable long bones. While it is methodologically possible to produce an MNI estimate its accuracy will be low because of the undiagnostic nature of the diaphysis.

Table 45: *Pteropus* sp. elements and body parts to symmetry (L= left; R= right) per unit for TP1B.

Elements/Body part	**Unit 1**			**Unit 2**			**Unit 3**			**Unit 4**		
	L	R	N/A	L	R	N/A	L	R	N/A	L	R	N/A
Mandible	0	0	0	0	1	0	0	0	0	0	0	0
Humerus	0	0	0	0	0	1	1	0	2	1	2	2
Radius	0	0	0	0	0	0	0	0	0	0	0	0
Ulna	0	0	0	0	0	0	0	0	0	2	1	0
Femur	0	0	0	0	0	0	0	0	0	0	0	0
Tibia	0	0	0	0	0	0	0	0	0	0	0	0
Fibula	0	0	0	0	0	0	0	0	0	0	0	0
Long bones	0	0	0	0	0	0	0	0	1	0	0	53
MNI	0	0	0	0	1	1	1	0	2	2	2	2

3.7 Class Reptilia MNI

The Class Reptilia includes both snakes and lizards. The lizards include the families, Scinidae, Gekkonidae, Varanidae, possibly Tiliqua and the *Eugongylus* species. The family Reptilia cranial specimens were analysed by herpetologists Mark Hutchinson and John Scanlon at the South Australian Museum (see Appendix 8). The post-cranial Reptilia were categorised in terms of body part and relative size.

Given the relatively low NISP of Reptilia specimens within the assemblage the snake and lizard axial elements were grouped together because of their broadly similar morphologies. They were classed into three categories (small, medium and large vertebrae), and were delineated on a non-metric (projected dimension) basis in order to account for fragmentation. The average weight of each class was distinctly different as expressed in table 45 and therefore supports the non-metric division.

The Reptilia long bones were interpreted as representative of lizards. They were not categorised in terms of species due to the lack of access to comparative collections. Anatomically each individual reptile had in the order of 40 (including cervical, thoracic, lumbar, sacral and caudal) vertebrae. Each Unit therefore contained a low MNI. Table 45 indicates that the Reptilia vertebrae NISP represents, except for the medium size class in Unit 4, no more than 1 individual per size class per unit. On face value the raw data suggest more lizards are deposited in Unit 4 than Unit 3. However, when corrected for years and volume of deposit there were more reptile long bones (representative of lizards) in Unit 3 than Unit 4 (see table 46).

Table 46: NISP and weight (gms.) of the Class: Reptilia vertebrae per size category per unit. Med. reptile = Medium Reptilia. 'Crectd' = per 1000 years/m^3.

Reptile size	**Unit 1**	**Crectd**	**Unit 2**	**Crectd**	**Unit 3**	**Crectd**	**Unit 4**	**Crectd**	**Ave Wt.**
Small Reptilia	1	N/A	1	N/A	9	6	13	1.6	0.19
MNI	1	N/A	1	N/A	1	N/A	1	N/A	N/A
Med. Reptilia	1	N/A	1	N/A	21	14	90	11.07	0.531
MNI	1	N/A	1	N/A	1	N/A	3	N/A	N/A
Large Reptilia	0	N/A	1	N/A	13	8.66	21	2.58	1.04
MNI	1	N/A	1	N/A	1	N/A	1	N/A	N/A

Table 47: Medium and large Reptilia (lizard) NISP per long bone element (utilising the element as the base unit) per unit. L= left; R= right.

Elements	**Unit 1**			**Unit 2**			**Unit 3**			**Unit 4**		
	L	**R**	**N/A**	**L**	**R**	**N/A**	**L**	**R**	**N/A**	**L**	**R**	**N/A**
Humerus	0	0	0	0	0	0	2	0	0	0	5	1
Radius	0	0	0	0	0	0	0	0	0	0	0	0
Ulna	0	0	0	0	0	0	0	0	0	0	0	0
Femur	0	0	0	0	0	0	0	0	0	5	5	0
Tibia	0	0	0	0	0	0	0	1	0	2	1	0
Fibula	0	0	1	0	0	0	0	0	0	0	0	0
Specimens (unknown)	0	0	0	0	0	2	0	0	27	0	0	34
MNI	0	0	1	0	0	1	2	1	14	5	5	17

The results in table 47 indicate decreasing long bone MNI over time. Unit 4 equals 9, Unit 3 equals 7 and Units 2 and Unit 1 equals 1 individual. The values corrected for years and volume indicate a similar trend to table 46 in which Unit 3 has a larger number of Reptilia than Unit 4.

3.8 NISP and MNI-Summary

The results reflect the quantity of each taxa by weight and number per unit through an analysis of both NISP and two versions of MNI. The taxa are listed in table 38 in terms of there relative contribution to the assemblage.

Table 48 summarises the results in terms of the relative dominance in the assemblage. The Megapteroptera were the dominant taxa in Units 3 and 4 and *P. orientalis* was the dominant taxon in Units 1 and 2 as is illustrated in figures 10 and 11 and are therefore the primary focus of the interpretations in the following Chapters.

Table 48: Buang Merabak main taxa in groups indicating relative quantity in TP1B. Group I = most common, Group II = medium quantity, Group III = least common

Group	**Taxa**
Group I	*P. orientalis*
	D. anderseni
Group II	Varanidae
	Eugongylus sp.
	Thylogale browni
	Pteropus sp.
	D. praedatrix
	Rodentia
Group III	Small lizard
	Micropteroptera
	Snake

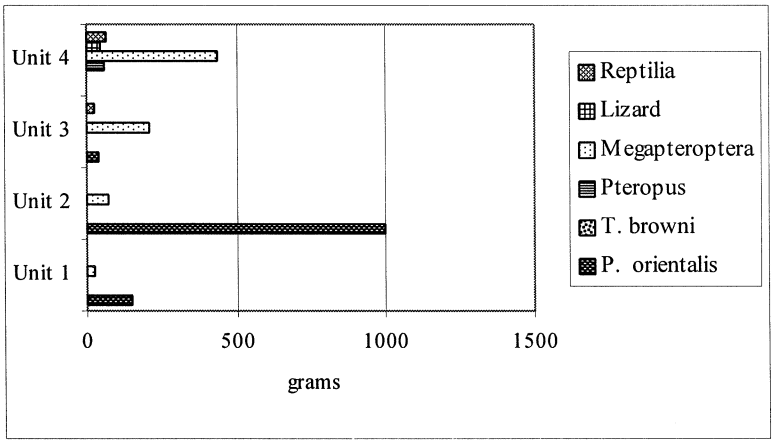

Figure 10: Buang Merabak TP1B weight per taxa per Unit.

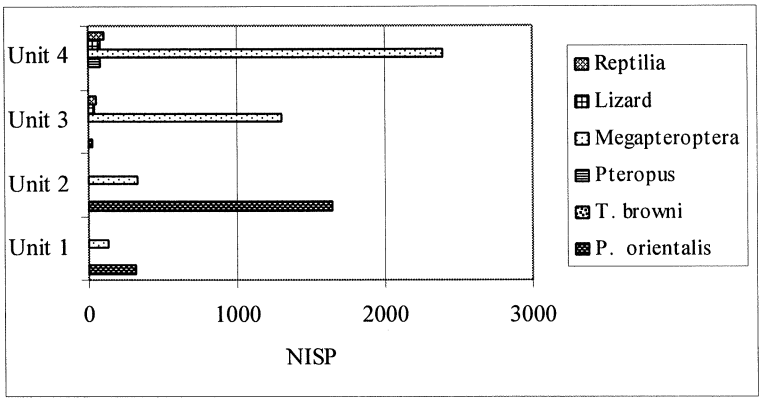

Figure 11: Buang Merabak NISP per taxa per Unit.

4. CONCLUSION

The results described above represent qualitative and quantitative analyses of the Buang Merabak TP1B faunal assemblage in terms of quantity per taxa per unit in relation to MNI, NISP. It provides a new technique for the calculation of the MNI value by counting sub-elements and compared the results with the conventional method of counting proximal, medium and distal attributes per element. The assemblage is analysed in terms of NISP and two methods of MNI in order to accurately estimate the quantity of individuals per taxa. Two taxa, *P. orientalis* and *Dobsonia* sp. (predominantly *D. anderseni)*, dominate the assemblage and they are the primary concern of the remainder of this dissertation. While this Chapter has analysed the assemblage in terms of the quantity of animals represented in TP1B it did not engage with the taphonomy issues that influence an assemblage. Chapter 5 aims to distinguish between the cultural and natural processes of deposition and Chapters 6, 7 and 8 investigate the nature of human behaviour.

Chapter 5
Taphonomic Analysis: Method and Results

1. INTRODUCTION

Archaeological deposits are the result of a complex combination of dynamic natural and cultural formation processes. In order to investigate the cultural processes that are a result of human behavior it is essential to gain an appreciation of the role of natural processes that are also represented within the assemblage (Dart 1957).

Taphonomy is the process of transfer from the biosphere to the lithosphere (Efremov 1940; Olson 1980:5). In the archaeological context it is important to identify the agents and processes that collected, deposited and transformed the faunal remains up until the point at which they were excavated (Lyman 1997:163). Strictly speaking, taphonomy refers to both the cultural and natural processes although in archaeological research taphonomic studies are commonly designed to emphasise the distinction between them. More specifically, it is essential to be able to distinguish the human prey refuse from the natural bone in order to obtain the clearest understanding of human behavior.

Previous analyses of other assemblages in the region have been content with statements such as "[s]ince there are no endemic bone accumulating scavengers...and the bones show little sign of rodent gnawing...nearly all the bone can be attributed to human consumption" (Wickler 2001:218). Assertions such as this rely heavily on the association of midden material with artefacts in conjunction with direct evidence of human behaviour such as cut marks on bones. However, cut marks do not occur on all archaeological bone assemblages. The Bird's Head analyses revealed no cuts marks on any elements (Pasveer 2003:187). Alternatively, some taxa were designated as the result of natural processes on the basis of their intrinsic characteristics. The Micropteroptera including the *Hipposideros diadema,* and the rodents are considered to be non-human contributions to the Kria and Toé Cave assemblages on the basis of their ecological association with caves (Pasveer 2003:194). The bulk of the remaining taxa in the faunal assemblage was the result of human behaviour because "non-human predators are rare in Papua New Guinea" (Pasveer 2003:183, 269). While the same might be said for New Ireland the remainder of this Chapter discusses and describes the methods utilized to delineate between the natural and cultural formation processes that produced the Buang Merabak deposit.

What follows is an examination of both the natural and cultural formation processes for the Buang Merabak bone assemblage and discussion about its preservation (Binford 1981; Johnson 1985) including human, non-human and geomorphic agents. In particular, the analyses focus on six criteria: depositional archaeological association, bone concentration, burning patterns, fracture patterns, mortality profile and cut marks.

The majority of natural animal deaths do not result in the survival of the bones (Butzer 1985:193). Animals approaching death are often old or unhealthy and succumb to predation. Non-human predators tend to consume their prey in ways that are not usually conducive to bone preservation. The remaining minority of bones that are present in the archaeological record are subject to one or a variety of either natural or cultural taphonomic processes that lead specifically to preservation. Natural processes, such as rapid post-depositional burial can lead to fossilisation and cultural processes, include predation and/or consumption by humans.

2. PRESERVATION

In order to investigate how the assemblage represents human behaviour it is vital to first consider the level of preservation at the site. It is essential to determine the extent to which the assemblage reflects what was initially deposited. Generally, the vast array of organic material collected during excavation (Balean 1989; Leavesley 1996; Leavesley and Allen 1998; Rosenfeld 1997) indicates a high level of preservation. What follows is a discussion about sediment alkalinity, levels of sediment solidification through calcification and the relative quantities of taxa that are considered indicators of relative preservation of organic material at the site.

The ability of sediment to preserve organic material within its matrix is reflected in the sediments 'potential of Hydrogen' (pH) as discussed in Chapter 3 (and Appendix 1). The Buang Merabak sediment pH ranges from 8.5 to 10, is mid-range alkaline and therefore considered to be very good for the preservation of organic material such as bone and shell.

Calcrete layers preserved in the site are important because they indicate the presence of sediment with good preservation properties. The relative rate of calcification changes over the depth of the deposit suggesting that its formation is not directly dependant upon time. The differential rate of calcification in the site is related to varying moisture levels within the sediment. Similarly changes in the colour of the sediment profile do not directly match the ^{14}C chronology and most likely reflect natural post-depositional processes.

The decomposition of bones occurs at a rate that has an inverse relationship between time and size. The presence/absence of small animal bones provides an indication of the preservational nature of the sediment matrix. In any environment the first bones to decay and disappear from the archaeological record will be those that are most fragile. Fragile bones tend to be those that are small or thin. For diaphyses they may have a relatively large medullary cavity, relative to bone thickness. Thus the presence of fragile bones indicates conditions conducive to the preservation of organic material within the deposit (Butzer 1985:197). If few small bones are collected then it may be inferred that the conditions are not suited to preservation if there is evidence that they were in fact deposited at the site in the first place.

The Micropteroptera bone NISP is greatest in Unit 4 at twice the quantity of Unit 3 by NISP and three times as large by weight and reduces over the following units. The presence of such a large number of Micropteroptera bones in the lower levels where they have been subject to post-depositional processes for the longest time suggests that site preservation is good.

A range of elements from small fish, bats and frogs was collected as part of the Buang Merabak bone assemblage. The smallest taxa are the Micropteroptera. They have relatively large medullary cavities and long thin bones to facilitate flight and are consequently extremely fragile. Assuming preservation uniformity based on the consistently high alkalinity levels in the deposit, it is argued that as the Micropteroptera bones have survived then bones of other similarly fragile taxa might reasonable be expected to have survived within the same matrix (see table 27).

3. DEPOSITIONAL ARCHAEOLOGICAL ASSOCIATION

The close spatial association of bones with artefacts in an archaeological context is considered a good general indicator that humans are one of the agents of site formation (Binford 1981; Bonnichsen 1989:2; Isaacs 1983; Potts and Shipman 1981). The rationale suggests bones are subject to the same depositional processes as the associated stone artefacts. Since it has been shown that archaeological deposits are the result of a combination of dynamic cultural and natural formation processes, arguments based on the association of stone artefacts and bones can be complex. Nevertheless, they do provide a starting point in attempting to differentiate between cultural and natural formation processes (Butzer 1985:194). Therefore the presence of artefacts can be considered indicative but not definitive evidence that cultural formation processes contributed to the accumulation of the fauna.

Table 49: Number and weight of stone artefacts per Unit. NAS=Number of Artefactual Specimens (Hiscock 2002).

Unit	NAS	Weight (gm.)	Ave wt. (gm.)
1	70	466.6	6.66
2	47	372.1	7.9
3	15	312.0	15.27
4	17	82.4	4.84
Total	149	1233.1	8.38
Ave.	37.25	308.27	N/A

The preliminary results of the stone artefact analysis seen in table 49 and Appendix 10 indicate stone artefacts are present at an average NAS of 37.25 per unit. In addition to the stone artefacts, two fragments of *Trochus* sp. shell arm ring (TP1B spits 8 and 9), 4 small garments of red slip, shell tempered pottery (TP1A spit 10 and TP1B spits 10, 23 and 17), two fragments of a grindstone (see below) and a drilled shark tooth were also identified in the deposit. Therefore, cultural accumulation processes clearly played a role in the accumulation of the deposit. An important limitation of this method was that it is a general indicator for the site but not for specific taxa within the site. The issue of whether different taxa were deposited by different mechanisms will be addressed below in the fracture analysis.

Figure 12: Drilled shark tooth (TP1B spit 35).

4. BONE CONCENTRATION

Caves are important archaeological sites because they may act as sediment traps. Once material is deposited inside the cave it remains relatively protected from the elements increasing the likelihood of long-term preservation. The higher the concentration, the more likely it is the result of active accumulation (Lyman 1997:190). Active or rapid accumulation tends to be the result of human behaviour (Lyman 1997:165-166). In order to gain an indication of whether the Buang Merabak assemblage reflects human behaviour it is compared with experimental data reflecting natural accumulation processes such as water flow and with data from other archaeological sites and site types.

Fluvial processes such as running and pooling surface water can cause accumulations of bone with similar densities that are identified by the presence and absence of certain bone elements and sediment analysis. A concentration of bones resulting from water flow will contain relatively more bones with low bulk densities because such bones tend to float more readily than bones with high bone densities (Lyman 1997:166). The first element(s) to become mobile under the influence of fluvial processes are the ribs, vertebrae, sacrum and sternum while the last are the skull and mandibles (Lyman 1997:172). Bone morphology may also influence an element's susceptibility to fluvial transportation. Behrensmeyer (1983), based on the work of Voorhies (1969), divided the elements into three groups reflecting mobility. Group I consisting of ribs, vertebrae, sacrum and sternum, are the elements likely to be affected first. Group II elements, (scapula, phalange and ulna) are the next most susceptible. They concluded that if the group I and II elements were present in the assemblage it indicated that fluvial processes did not extensively influence the assemblage.

Studies of element presence and absence reflect broad scale events and therefore require large datasets so as to minimise the impact of any single event. Of the sixteen taxa in the Buang Merabak assemblage the *Phalanger orientalis* is the most abundant and therefore the best dataset for this analysis. Units 3 and 4 contain very little *Phalanger orientalis* bone and therefore will not be considered further. Of the Group I elements (see table 29), Unit 2 contains slightly more than 10 times the number of elements as Unit 1. Both Units contain a substantial number of ribs and vertebrae. Sternum elements are present in both Units and sacrum element was absent. Of the Group I and II elements, the NISP of phalanges is low while scapulae are present and ulnas are plentiful. Although there is some disparity this evidence most strongly supports a non-fluvial accumulation process.

The rate of activity has been utilized as an indicator of human use of a site. Humans commonly re-use sites, leading to the *active accumulation* of debris such as bones. Therefore a large density of material within a deposit can be considered as a broad indicator of human behaviour. Conversely, natural traps, such as bogs or water holes tend to accumulate large amounts of bone and have been termed *passive mass accumulation* sites (Lyman 1997:191). They act like magnets to sick and dying animals: for example, non cave natural sites such as swamp environments exhibit build-up rate of 0.0083 NISP/m^2 while bush sites exhibit in the order of 0.002 NISP/m^2 in southern Kenya (Behrensmeyer 1983). Buang Merabak does not contain any features that might be described as a natural magnet to *P. orientalis*. Chiroptera use the inner chambers for roosting which may result in the natural accumulation of Chiroptera bone. A site such as Nombe provides useful comparative data for the Buang Merabak assemblage because it is an archaeological site that was occupied for 21,000 ^{14}C years (Mountain 1991:10.1), which is a similar amount to Buang Merabak that represents 22,000 ^{14}C years. Nombe contains 11,310 gms of bone in 732 litres of deposit and is equivalent to 15,450 gm/m^3 of wet-sieved bone. It contained 34,847 gms of bone in 14,688 litres equivalent to 2372 gm/m^3 averaging 2993 gm/per m^3 overall (Mountain 1991: Table 6.1). In terms of this comparison the greater the concentration, the more likely it is the result of cultural accumulation processes (Lyman 1997:190). Table 14 indicates that the Buang Merabak bone accumulation rate increased over time. On average the faunal deposit accumulated at 2241.1 gm/m^3 and is therefore comparable to the average concentration of bone at Nombe suggesting that on this basis the Buang Merabak assemblage is consistent with a culturally derived deposit.

Bone scattering is also an important consideration in analysing the degree to which faunal assemblages have been influenced by natural accumulation processes. Bone density data is also instructive in considering notions of bone assemblage scattering. There is a direct relationship between the number of predators/scavengers and the distance over which the assemblage is scattered. The more scavengers, the greater the scattering (Lyman 1997:147). Birds contribute to site formation processes through both depositing scats and post-depositional scavenging. The latter particularly serves to scatter bones across the surface of a site (Lyman 1997; Solomon et al. 1986). Raptors (*Ninox* and/or *Tyto* sp.) and bowerbirds (*Archboldia* sp., *Chlamydera* sp. or *Amblyornis* sp.) are possible agents of accumulation, but New Ireland has no recorded bowerbirds (Mayr and Diamond 2001) and at least one owl, the *Ninox Solomonis* (Leavesley and Leavesley 2000:70) and two extinct Tytonids (Steadman et al. 1999:2565). The relatively highly calcified nature of the bone assemblage effectively masks evidence of raptor scats (Marshall 1986) and the quantity of Rodentia specimens within the assemblage is relatively low, so will not be pursued further. Alternatively, bowerbirds although they are absent from New Ireland are known to collect a variety of material from within their bush habitat and therefore must be considered as possible dispersers or scatterers of bone. The high density of bone in the site suggests a low amount of scattering indicating non-human predators.

In summary, the bone density results indicate predominantly human deposition of the bone assemblage at Buang Merabak.

5. FRACTURE ANALYSIS

"*It cannot be assumed that all split and fractured bone on an archaeological site has been broken by man*" (Clark 1972:149).

Animal products are utilized by humans for a variety of resources including skins for clothing, bone for tools (Pasveer 2003) and most commonly for the nutrition that is obtained primarily from the meat but also the bones (Lyman 1997). Meat consumption commonly requires skeletal disarticulation and the fracturing of the adjoining bones. The dietary value of meat is highest when it is fresh. Meat is freshest immediately upon or after death and before bacteria begins to putrefy the meat. Upon death the carcass begins the transformation from the biosphere to the lithosphere. Part of the process entails the dehydration of both the flesh and bone of the carcass. The dehydration process manifests itself as a transformation from a hydrous material into an anhydrous material (Johnson 1985:160) and can occur in a matter of days in the tropics (Butzer 1985: 196-197). The moisture content of the bone has a direct bearing on its elasticity. The bone of a living organism is relatively elastic while the bone of a dead organism soon becomes dehydrated and relatively brittle. The climatic conditions in the tropics reduce the amount of time after death in which meat can be retained before putrification makes the meat inedible to humans. The morphology of the fracture reflects the relative dehydration of the bone at the time of the fracture (Davis 1987). A bone fractured during life or immediately post-mortem reflects specific characteristics consistent with a hydrous bone and a fracture on a dehydrated bone reflects different features (Lyman 1997:316).

While fracture analysis can be utilized to distinguish between processing and/or consumption on the one hand and natural death and/or post-depositional bone alteration it does not purport to distinguish between the predators themselves. In addition to humans, New Ireland has few potential predators of *P. orientalis.* Table 50 lists the potentially raptors. Elsewhere owls are commonly cited as potential contributors of rodent bone to cave deposits (Marshall 1986; Marshall and Allen 1991) and ethnographic evidence, from the Asmat region of southern New Guinea, indicates that Aves may consume small lizards (Bergman 1961:140). Raptors such as *Ninox solomonis* generally prefer smaller prey than *P. orientalis*. However, Rodentia and small lizards contribute only a very small part of the assemblage and therefore are not investigated further. Of the other Aves, only the *Haliaeetus leucogaster* has been reported to consume *P. orientalis* (Heinsohn 2000). Heinsohn (2000) reports somebody else's observation and therefore the suggestion that *Haliaeetus leucogaster* hunts *P. orientalis*, awaits corroboration.

Table 50: New Ireland Avian predators.

Latin name	Common name
Aviceda subcristata	Crested Hawk
Accipiter novahollandiae	Grey Goshawk
Haliastur indus	Brahminy Kite
Haliaeetus leucogaster	White-Bellied Sea Eagle
Ninox solomonis	Bismarck Boobook Owl
Pandion haliaetus	Osprey
Tyto sp.	Extinct Owl (Steadman et al. 1999)

Of the New Ireland reptiles it is not clear whether the *Varanus indicus* may be large enough to capture small *P. orientalis;* equally it is unclear to what extent to which it utilizes cave habitats. However, it is nevertheless unlikely that evidence of reptile behaviour is going to have an impact on fracture analyses. Reptilia eat their prey whole and their digestive tract alters the entire animal into an unrecognisable paste and therefore its contribution is difficult to identify in the archaeological record. Other potential predators were the Crocodylae, but it does not commonly either consume *P. orientalis* and remove the bones for deposition or utilize caves. *Canis familiaris* was not extant in New Ireland until Unit 1. The average weight of *P. orientalis* post-cranial specimens dropped from 0.60 grams in Unit 2 to 0.48 grams in Unit 1 (table 38) suggesting the possibility of *Canis* sp. scavenging. However, the assemblage exhibited no evidence of *Canis* sp. gnawing leaving humans as the only predator of *P. orientalis* that exhibits behavioural traits conducive to systematic bone discard. Therefore, the green/dry fracture dichotomy can be utilized to distinguish between those bones that were deposited by cultural or natural processes with a high degree of certainty because there are no alternative predators in New Ireland.

A green fracture is the product of the application of force to a bone before or immediately after death but before the process of dehydration makes the bone brittle. It exhibits characteristics that are distinct from those exhibited by the fracture of a dry bone and is characterised by an oblique fracture angle, sawtooth morphology and rough surface that is the same colour as the external bone surface (Lyman 1997:318; Marshall 1986:14).

Once the requisite period of time passes (different bones take different lengths of time after death depending upon their specific characteristics) the bone becomes relatively anhydrous and therefore brittle. When force is applied to a brittle bone the fracture pattern is characterised by a perpendicular angle, smooth texture and a lighter fracture surface colour than the rest of the external surface of the bone (Lyman 1997:317-320; Marshall 1989:14; Shipman et al. 1981).

Fracture morphology is rarely unambiguous (Shipman et al. 1981:260). This is partly because the process of dehydration is continuous and therefore the fracture reflects a continuum between hydrous and anhydrous. Constructing divisions within a continuous scale is necessarily relative. Therefore, the differentiation between green and dry fractures is also relative.

Bone morphology also plays a role in fracture mechanics. The shape of the bone has a direct influence on the way the force travels through it. A homogenous cylinder is the most amenable shape for the production of definitive fracture patterns because the force can travel evenly through the bone. Femur diaphyses best reflect the fracture criteria because of their relatively cylindrical homogenous morphology as opposed to other diaphyses and epyphyses. Also static loading, that is, constant compression, will cause different fracture morphologies to dynamic (sudden impact) loading (Johnson 1985: 170, 192; Lyman 1997:316). As animal bones are not homogenous cylinders the results of fracture analyses reflect a high probability of the fracture fitting into one or another of the fracture types rather than a definitive replica. These aspects of bone fracture mechanics are taken into consideration in this research as discussed further below.

The most common reason for the fracturing of bone is to facilitate the extraction and consumption of meat by a predator. The process of post mortem dehydration on a carcass affects the nutritional value of the meat. The longer the dehydration process occurs the less nutritional value contained in meat. Fracture patterns are interpreted as reflecting the amount of time between the prey's death and the time at which the bone was broken. The optimal time to consume the meat is immediately after the prey's death and coincides with the time at which the bones, if force is applied, will exhibit green fractures. Therefore, green fractures are interpreted as reflecting the consumption of the prey by a predator. In order to determine whether a fracture is green or dry it is rated on the basis of five criteria. They are: angle, outline, colour, texture and calcification (see table 51).

Table 51: Criteria utilized to distinguish between 'green' and 'dry' fractures (Lyman 1997:318-320).

		Angle	**Morphology**	**Texture**	**Colour**	**Calcification**
Green	***Green***	Oblique	Spiral, sawtooth or irregular	Rough	Same as bone exterior	Possibly calcified
Dry	***Old dry***	Right	Stepped, V-shaped, longitudinal, perpendicular or irregular	Smooth	Lighter than bone exterior	Possibly calcified
	Recent dry	Right	Stepped, V-shaped, longitudinal, perpendicular or irregular	Smooth	Extremely light	Not calcified

'Angle' refers to the degree to which the fracture surface differs relative to the longitudinal axis of the bone (Lyman 1997:318) and is separated into two categories, being either oblique or a right angle. The oblique fracture angle reflects the presence of moisture in the bone and increases the likelihood that it is a green fracture and a right angle reflects a lack of moisture and is indicative of a dry fracture.

The 'morphology' criterion refers to the shape of the fracture surface and is identified in relation to seven categories. They are: 'spiral', 'stepped', 'v-shaped', 'sawtooth', 'longitudinal', 'perpendicular' or 'irregular'. The spiral fracture is helical in shape while the sawtooth fracture is jagged. Both represent a green fracture (Johnson 1985). The stepped fracture has a number of right angles not dissimilar to a staircase. The v-shaped fracture comes to a point. The longitudinal fracture runs along the length of the bone commonly at right angles to its length. And the perpendicular fracture is a right angle. The four latter fracture types are all indicative of a dry fracture. The irregular category includes those specimens that do not clearly fit into either of the above.

The 'texture' refers to the fracture surface and can also be compared to the external surface of the bone. A green bone fracture produces a rough surface and a dry bone produces a smooth surface (Lyman 1997:319; Marshall 1989).

The 'colour' refers to the shade of the fracture surface relative to the external surface of the bone. Assuming uniform colour alteration (as part of long term taphonomic processes) the fracture will be the same colour as the external surface of the bone if it broke as part of the same process that removed the flesh. Alternatively, if the fracture occurred sometime after flesh removal then it will exhibit a different (commonly lighter) colour and is interpreted as having occurred sometime later.

All the bones in the assemblage are to some extent subject to the process of calcification in which calcium carbonate particles in the sediment adhere to each other and anything else in the sediment profile. The fracture surfaces are assessed to determine to what extent they had calcium carbonate attached to them. If they are calcified it was interpreted as reflecting a long period of time since the fracture occurred. However, if they were not calcified it does not mean that there were necessarily more recent fractures, only that they were not in a specific micro-environment conducive to calcification. Therefore, calcification can only positively identify a long period of time since fracturing.

While the data from each criterion can be interpreted in isolation the best results are obtained from using them in combination. Equally, some criteria were considered more reliable than others and were rated from most to least reliable. The most reliable were morphology and fracture angle, followed by colour and texture. Morphology and angle were the most reliable because they are directly related to bone elasticity. The fracture texture is also related to bone elasticity but is relatively subtle and therefore differentiation necessarily occurs at a finer scale. Fracture colour is the least reliable criterion because it occurs as a post-fracture process, and therefore indirect factors such as sediment, mineral content and weathering influence the colour.

Each bone specimen within the assemblage typically exhibited between one and three separate fractures, although some exhibited none or up to five (particularly on cranial specimens). The assemblage contains in the order of 57,000 fractures (estimate based on the sample) and a random sample of 4506 fractures (7.9%) is listed in table 52.

Table 52: Fractures by category per unit for all taxa in TP1B. The estimated fractures per unit assumes an average of 2 fractures per specimen.

Unit	Green fractures	Dry fractures	Recent fractures	Total	Green as % total unit fractures	Estimated fractures per unit	% recorded/ unit total
1	105	343	120	*568*	18.50	5,598	10.14
2	584	1794	352	*2730*	32.55	18,846	14.40
3	76	196	52	*324*	23.45	11,582	2.79
4	294	467	123	*884*	33.25	21,150	0.04
Total	*1059*	*2800*	*647*	*4506*	N/A	57,176	N/A

Table 53: Fractures per category per unit per 100 fractures.

Unit	# green per 100 fractures	# dry per 100 fractures	# recent per 100 fractures
1	18.48	60.38	21.12
2	21.39	65.71	21.89
3	23.40	60.49	16.04
4	33.25	52.82	13.91

The percentage of green fractures, representing human consumption behaviour, ranged from between 33.25% in Unit 4 and 18.5% in Unit 1 for all taxa (see table 52). The same data re-calculated to account for differential total fractures per unit and adjusted to reflect the number per 100 fractures supports the trend towards lower numbers of green fractures over time (see table 53).

Fracture analysis data can be interpreted to inform whether different taxa were subject to different fracturing regimes. They differentiate between processing/consumption and natural death, particularly for taxa that occupy the same ecological zone as the human prey and maybe fractured by either human consumption or as a result of natural disarticulation processes. For example, cave dwelling Chiroptera such as: *D. anderseni, D. praedatrix* and Megapteroptera occupy caves and therefore it is possible that a percentage of the population may die in the cave environment. If the bat bones within the assemblage are predominately the result of natural death they will exhibit a very high quantity of dry fractures. Table 54 lists the number of fractures per taxa per unit and the percentage of green fractures per the total number of fractures for each unit for selected taxa.

Table 54: Number per fracture category per taxa per unit in TP1B. Gr = Green fracture; Dry =dry and recent.

Taxa	Unit 1		Gr % total	Unit 2		Gr % total	Unit 3		Gr % total	Unit 4		Gr % total
	Gr	Dry		Gr	Dry		Gr	Dry		Gr	Dry	
P. orientalis	89	351	20.22	523	1,599	24.64	11	44	20.00	0	0	0
D. anderseni	0	0	0	15	18	45.45	13	30	30.23	33	40	45.20
D. praedatrix	0	0	0	0	2	0	0	0	0	3	8	27.27
Megapteroptera	2	18	10.00	20	83	19.41	11	50	18.03	33	144	18.64
Reptilia	0	1	0	0	3	0	0	54	0	17	115	12.87

Table 55: Number per fracture category per unit per selected taxa. The Megapteroptera category includes all family: Pteropodidae specimens not identified to genus. U= Unit; Gr =green fracture; R = recent fracture.

Taxa	U 1			U 2			U 3			U 4		
	Gr	Dry	R	Gr	Dry	R	Gr	Dry	R	Gr	Dry	R
P. orientalis	89	295	56	523	1336	263	11	39	5	0	0	0
D. anderseni	0	0	0	15	17	1	13	26	4	33	30	10
D. praedatrix	0	0	0	0	1	1	0	0	0	3	7	1
Megapteroptera	2	10	8	20	67	15	11	48	2	33	133	11

The data in table 52 support an interpretation that more green fractures are present in Unit 4 than the subsequent Units. The percentage of the (combined dry/recent) fractures ranged from 66.73 % in Unit 4 and increased over time to 81.5% in Unit 1 and represent post-depositional behaviour. While there is no direct indication of the cause of the dry and recent fracturing it might be interpreted as representative of trampling or a reflection of the long-term increase in the weight of the sediment overlying the assemblage.

If the sediment weight was the primary cause of the dry/recent fracturing it might be expected that there be a greater number of fractures in Unit 4 than Unit 1 because it has the highest weight bearing Unit. However, if trampling is the cause of the dry/recent fractures then we might expect it to increase at a similar rate to the increase in deposition, as a proxy for human use of the site. The data in table 13 suggest that the rate of deposit increases relatively steadily over time and therefore, it is likely that trampling is the primary cause of the 'dry' fractures.

The fracture analysis data reflecting the distinction between fractures that occurred at or near the death of the animal and those that occurred later inform notions of human consumption but not predation.

The results in tables 52 and 53 indicate the prevalence of green to dry fractures per taxa per unit in TP1B. For *D. anderseni*, *D. praedatrix* and Megapteroptera in Units 2, 3 and 4 the percentage of green fractures varies from between 18% and 45% and generally increases with depth/age. Green fractures are considered as indicative of breakage at the time of death and indicate consumption by humans because there are no other predators in New Ireland. The relatively high percentages in the lower three units suggest the Chiroptera were deposited by human behaviour. It also suggests a greater emphasis on Chiroptera in Unit 4 than in Unit 1.

The *P. orientalis* was absent from Unit 4 and therefore there was no fracture data for that Unit. Of the *P. orientalis* fractures between 20% and 25% per Unit exhibited green fractures suggesting they occurred during consumption by human predators. The results reflect the disarticulation of a hydrous carcass. Bone is hydrous during life and for a relatively brief period of time after the animal's death. As described above, breakage of hydrous bone is interpreted as a reflection of carcass disarticulation associated with meat consumption indicating preparation and/or consumption by humans. Between 75% and 80% of all fractures on the taxa occurred after the bones had dehydrated and reflects post-depositional processes at the site.

Reptilia fractures were low in Units 1 and 2 reflecting the taxa's low contribution after the Last Glacial Maximum. Of the 54 fractures in Unit 3 none exhibited evidence of green fracturing. In Unit 4, 13% of fractures were green suggesting they occurred during consumption. The Unit 3 Reptilia were 100% dry/recent fractures suggesting they did not occur during consumption and therefore were not the result of human behaviour.

6. TOOTH ENAMEL WEAR ANALYSIS

The age profile of the prey population is instructive when investigating resource use and hunting strategies because it reflects the general age of the prey population at death. Tooth wear analysis is the most accurate way to produce an age profile because following tooth eruption, and as part of the natural process of mastication, the crowns of opposing teeth rub on each other producing wear marks, commonly in the form of grooves and pits on opposing enamel surfaces. Over time the tooth enamel sustains wear that eventually exposes the underlying dentine. The quantity of tooth wear is directly related to the quantity of mastication. Assuming the level of mastication is constant throughout the life of an animal, tooth wear represents time since the tooth erupted. However, a number of factors can influence the results of enamel wear analyses. Diet plays an important role because different plant taxa consist of different ratios of harder constituents, such as fibres or phytoliths and softer constituents, commonly associated with high moisture content present in more succulent foliage. The mastication of fibrous plant taxa results in a relatively higher rate of enamel wear than consumption of more succulent plant taxa (Winter 1980). In order to produce internally consistent data it is important that the diet is consistent over the entire population in the study. The populations analysed in this study are from a single archaeological site probably representing prey captured from within the local region. New Ireland's rainforest has probably not significantly altered since the Last Glacial Maximum and therefore its inhabitants are likely to have had a similar diet over time and therefore the data are likely yo be internally comparable.

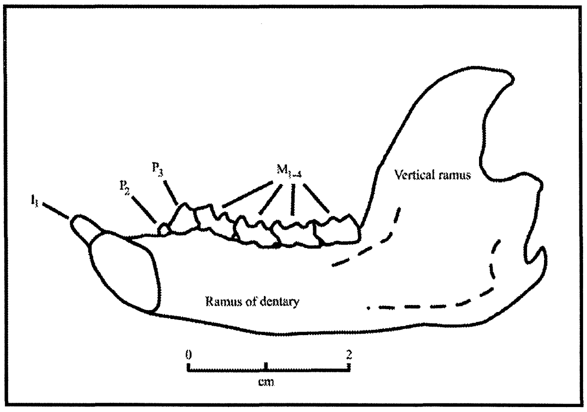

Figure 13: *Phalanger orientalis* lower right mandible indicating the location of the P3 in relations to the molars.

Another influence on tooth wear is that different teeth can wear at different rates depending on their morphology and position in the mandible or maxilla. The muscular structure of the teeth and jaw dictates that more force is exerted on the anterior teeth than the posterior teeth. Therefore, dentine exposure will occur sequentially from the premolar to the first through to the fourth molar (see figure 13).

Table 56: *Phalanger orientalis* NISP per molar per Unit for TP1A and TP1B.

	M_1	M_2	M_3	M_4
Unit 1	49	43	42	29
Unit 2	121	107	71	38
Unit 3	38	25	15	10
Unit 4	4	5	4	2

If the assemblage contains a greater number of anterior molars than posterior molars then the data will be skewed towards the identification of older animals and vice versa. The extent of this problem is tested by a comparison of the NISP per tooth per unit. As part of this project and demonstrated in table 56 and illustrated in figure 14 (Leavesley in prep.), the assemblage does not contain a significantly different number of molars across the Units. At 9 degrees of freedom chi-square is 10.48 ($p=\leq 1$). For significance at the 0.05 level, chi-square should be greater than or equal to 16.92. The molar distribution is not significantly different across the Units and is therefore likely to have little impact on the overall results. In this dissertation wear analysis was carried out only on *P. orientalis* because it was the only taxon with a large enough number of specimens to provide a meaningful dataset.

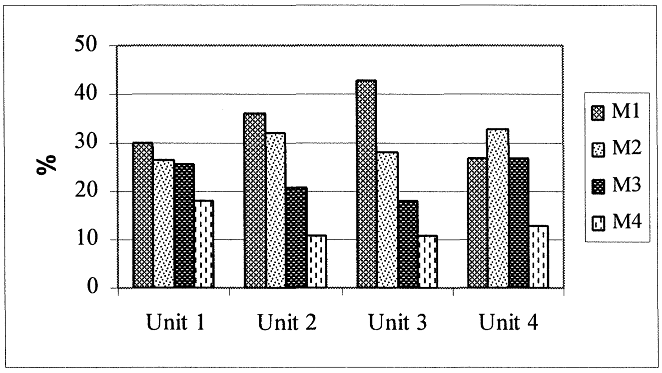

Figure 14: Phalanger orientalis % NISP (from table 56) per molar category per unit in TP1A and TP1B.

Tooth morphology also plays a role in tooth wear patterns. Where the crown is narrower the force exerted on it during mastication is relatively more concentrated resulting in an increased rate of wear on a smaller area and consequently an increased rate of dentine exposure. Alternatively, where the crown is relatively flatter, the force is more dispersed and dentine exposure occurs at a relatively slower rate. For *P. orientalis*, the 3rd premolars (P^3 and P_3) are high with pointed crowns and therefore will exhibit dentine exposure on the tip of the crown earlier than on the four molars. The four molars have very similar shaped crowns suggesting minimal differential wear based on tooth morphology.

While there are no tooth wear data for extant *P. orientalis* populations there are for other taxa within the family Phalangeridae (Kingsmill 1962; Winter 1980). Winter (1980:360) identified seven classes of dentine exposure that serve as the basis for the four classes utilized below (see table 57). They are simplified for this analysis in order to reduce observer error and maximise accuracy.

Table 57: Summary description of the tooth wear categories.

Wear category	**Description**
a) None	No exposed dentine
b) Low	Minimal exposed dentine
c) Intermediate	Small crescents to transverse bands
d) High	Obliterated crowns

Wear category 'a) None' includes teeth that do not exhibit any exposed dentine. This class may show signs of wear that crucially, do not penetrate the enamel. Wear category 'b) Low' includes teeth with minimal exposed dentine on the tops of high cusps. Wear category 'c) Intermediate' includes teeth within the range of having small crescents of dentine exposure to a broad band of dentine exposed across both the lingual and labial cusps. Wear category 'd) High' includes teeth of which the crowns are completely obliterated and dished.

Compared to zoological collections, archaeological assemblages have two important limitations. First, as a result of the combination of cultural and natural formation processes, archaeological assemblages are highly fragmented and therefore it is difficult to accurately determine the number of individual animals that contributed to the assemblage. It is also difficult to accurately determine how many fragments originally came from each individual animal. For this study, each specimen is treated individually for tooth wear irrespective of whether it contains one or all four molars. Potentially this allows for a single individual animal to be recorded more than once inflating the overall sample size.

A mortality profile reflects the age of each individual prey animal and cumulatively the prey population at the time of death. If predators have played a role in the accumulation of the dead animals then the age profile of the dead animal assemblage will reflect the relationship between the predator and prey. It has been proposed that hominid hunting will result in a high proportion of juveniles amongst the prey assemblage (Speth 1991:39; Stiner 1991). The rationale is that juveniles are the last to respond to danger, have the most naïve evasion responses, are the slowest over distance and are generally at the end of the line of escaping animals and therefore are the easiest prey to capture. While this model is most applicable to herding animals all the criteria are equally applicable to all potential prey taxa. This model is compared with an age profile derived from the Buang Merabak *P. orientalis* assemblage in order to determine whether it is consistent with a natural population or the prey of human predators.

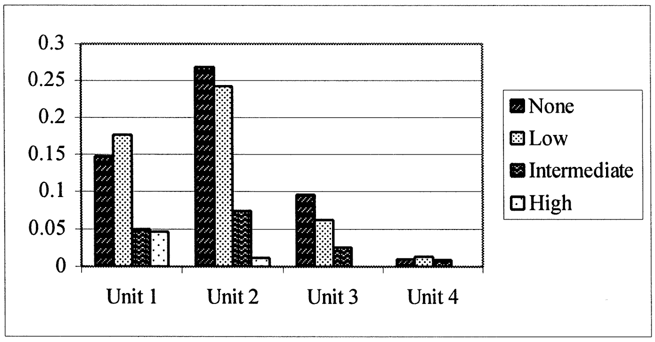

Figure 15: *Phalanger orientalis* mortality profile in wear categories per Unit per 1000 years (data from table 57).

When a tooth is fully erupted, the enamel is fully exposed above the alveola. If the tooth has not fully erupted, part of the enamel is obscured, from vision, by the alveola. If the tooth has left the alveola post-mortem, the alveola can still be classed in terms of eruption. During the process of eruption the alveola changes shape as the ramus of dentary (see figure 13) extends and the teeth move forward into position. If a specimen died prior to the completion of the tooth eruption process and the teeth have left the alveola post-mortem the alveola exhibits a form that is indicative of the fact that the teeth had not fully erupted. Therefore, a specimen can be classed under the 'eruption' criteria with or without the presence of a tooth in the alveola for either a mandible or maxilla.

Unit 3 contains a small number of cranial fragments (and a large number of post-cranials). The small quantity of specimens makes it difficult to extrapolate beyond the very general trends reflecting the predation of *P. orientalis*. Unit 2 reflects an overall increase in the quantity of animals captured and a tendency towards the capture of younger animals. Unit 1 reflects an overall reduction in the number of animals captured and a movement away from animals in category 'a) None' to category 'b) Low' indicating a increase in the average age of individuals from very young to young. The results of a chi-square test indicate that the values are not significantly different. At 6 degrees of freedom, chi-square = 6.83. For significance at the 0.05 level, chi-square should be greater than or equal to 12.59 ($p = \leq 1$). Therefore the distribution is not significantly different.

Table 58: Number per tooth wear category for *P. orientalis* in TP1A and TP1B.

Wear categories	**Unit 1**	**Unit 2**	**Unit 3**
a) None	2	46	1
b) Low	11	51	3
c) Intermediate	2	17	2
d) High	1	2	0
Total	16	116	6

6.2 Mortality Profile Discussion

After the initial introduction of the cuscus into New Ireland, at 20,000 bp, the NISP of cranial and post-cranial fragments increase and peak in Unit 2 before decreasing in Unit 1 (see tables 16 to 21). The Unit 3 to Unit 2 data clearly reflects a general increase in the consumption of the cuscus at Buang Merabak because overall deposition slows after Unit 3 (see tables 18 to 21).

The mortality profile indicates that overall, young animals generally dominated the assemblage. Table 58 indicates that over successive units, from Unit 3 to Unit 2, the quantity of young animal's increases over time. Taken in consideration with figure 14, the data suggested that the NISP of animals designated as having 'low' or no dentine exposure increased as the NISP of dentary fragments increases. This trend emphasizes the dominance of the smaller animals in the catch.

7. CUTMARKS

Cut marks were the most direct means of linking humans to bone assemblages (Binford 1981). Cut marks directly reflect the disarticulation of the skeleton and removal of the flesh from the bones of an animal with a blade. Cut marks were identified by observation either with the naked eye or under a low-powered microscope. They are indicative of human butchering (Lyman

1997:169-170; Marean and Assefa 1999) and by extrapolation, consumption. All specimens that were attributed to taxa were also analysed for cut marks. Cut marks were difficult to identify in the assemblage because the elements were relatively small and the larger taxa (*Thylogale* sp. and *Pteropus* sp.) were not present in high quantities.

Table 59 indicates that while cut marks were present in all units they occurred at a low rate suggesting the animals were generally disarticulated with minimal use of a cutting edge. In the Buang Merabak assemblage cut marks are recorded on *P. orientalis*, Megapteroptera and shark bones.

Table 59: Number of cut marks per taxa per Unit for TP1B.

Taxa	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**
P. orientalis	6	25	1	0
Chiroptera	0	3	0	1
Shark	1	0	0	0
Total	7	28	1	1

The TP1B assemblage exhibited 37 cut marks each recorded on individual bone fragments (see table 59). Unit 2 contained 75% of all cut marks while Units 3 and 4 contain one example each. Cut marks were more prevalent on animals that were difficult to disarticulate without tools. The largest prey species is the *Thylogale browni* weighing in the order of 7 kg and on average at least twice the size of the next largest New Ireland taxa. It is represented by a relatively low NISP. The low NISP may be the reason why there are no cut marks recorded on *T. browni* bones. A high proportion (86%) of cut marks was recorded on *P. orientalis* bones (see table 59). The low number of cut marks in the rest of assemblage may reflect the fact that the taxa are easily broken without the use of a sharp edge. Nevertheless, cut marks, even in low quantities, are indicative of human behaviour.

8. BURNING

The presence of burning on archaeological bone is conventionally seen as a prime indicator of human activity although the relationship is more complex than previously thought. Burning was considered to reflect either meat cooking, post cooking disposal or both. Boiled meat will in some instances reflect the boiling process on the bones. A carcass that was placed directly on a fire may reflect burning on the exposed bone. Furthermore, bone can be burnt after the meat is consumed or used as fuel for subsequent fires and this probably accounts for much of the burning evident on archaeological assemblages.

Burnt bone is identified by the discolouration of the bone and generally has a white/grey blue appearance (see figure 16). Each specimen that exhibited, at the very least, partial signs of burning was recorded in this category. No attempt was made to distinguish between human controlled burning and natural burning (Bellomo 1993). Tables 60 and 61 list the NISP of burnt bone per unit and body part, for the *P. orientalis*.

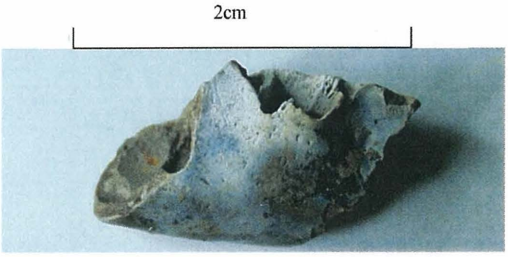

Figure 16: Burnt *Phalanger orientalis* mandible (TP1B, Spit 7).

The data in table 60 indicate a general trend of increased burning over time. If burning was primarily a post-depositional disposal process it might be reflected by an inverse relationship between the quantity of burning per Unit and the quantity of bone per Unit. More burning equals less bone. Units 3 and 4 had the lowest rates of burning with the former marginally outscoring the latter on corrected results. Unit 2 indicates an increase in burning from Unit 3 of 13:1. Unit 1 increases again at a rate of between 5 and 10:1. The burning model was consistent with Units 1 and 2 because Unit 1 contained a greater quantity of burning and a smaller quantity of bone than did Unit 2.

Table 60: NISP and weight of bone from all taxa exhibiting burning in TP1B per unit. Crtd = corrected for volume/1000 years.

	Unit 1	Crtd.	Unit 2	Crtd.	Unit 3	Crtd.	Unit 4	Crtd.	Total
NISP	235	345.58	76	33.78	4	2.67	21	2.58	336
Weight (gm)	69.94	102.85	22.61	10.04	1.07	0.71	6.07	0.75	99.69

In the process of food preparation and consumption burning on bone is highly dependent upon the way in which the animal is processed. If the carcass is not disarticulated then burning of the bone may occur only on the skeletal and/or element extremities such as the metacarpals, metatarsals and the anterior mandible region. However, if the carcass is disarticulated then burning may occur on any exposed bone. Alternatively, if the limbs are cooked separately then burning is more likely to occur on the exposed epiphyses as they have the least amount of flesh providing limited insulation against fire. Burning may also exhibit human post-consumption disposition. In order to test the proposition that burning was post-depositional the results from the *P. orientalis* are presented separately. This is because they reflect both an important ethnographic protein source and they contribute a large proportion of the assemblage. The nature of cooking might be investigated by an investigation into the distribution of burning between body parts. An equal distribution of burning between body parts might be expected if bones were randomly discarded into the fire and vice versa.

Table 61: NISP of burnt bone per body part per unit for *P. orientalis* in TP1B. % = body part per unit; Ratio = Unit 1: Unit 2.

Body part	**Unit 1**	**%**	**Unit 2**	**%**	**Ratio**
Cranial	7	41	4	9	1.7:1
Axial	0	0	2	4	N/A
Girdle	2	12	5	11	0.4:1
Long bone	8	47	35	76	0.23:1
Total	17	100	46	100	N/A

Table 61 lists all burnt *P. orientalis* bone in TP1B. Unit 2 contains 2.7 times the quantity of burnt bone than Unit 1 and a higher percentage of long bones. In contrast, Unit 1 contained a similar percentage of long bones as cranial fragments. A chi-square formula was utilized to test whether the quantity of burning on cranial and long bone specimens was significantly different. The results indicate the values are significantly different. At 1 degree of freedom, chi-square = 8.85 ($p = \leq 0.01$). Therefore the quantity of burning on long bones was significantly greater than burning on the cranial elements.

In order to investigate if the burning is indicative of disarticulation during processing and consumption of the carcass the data reflecting the NISP of burnt bone per body part per unit for the *P. orientalis* data are presented in table 60. The 'cranial' body part includes all the head bones, 'axial' includes the vertebrae and ribs, 'girdle' includes the scapula and pelvis and the 'long bones' include the limbs. Table 61 indicates that long bones and cranial elements exhibit the most burning. This is more consistent with burning as a result of processing for consumption rather than burning the bones as fuel for subsequent fires. Therefore, it is suggested that the burning pattern is consistent with human consumption behaviour rather than disposal behaviour.

Burnt bone, listed in table 60, was present in small numbers throughout all four units. Unit 1 contained 70 % of the total burnt bone and was the largest quantity of any unit. The presence of burnt bone suggested that fire, conventionally considered to reflect human behaviour, occurred in the site at an increasing rate over time. The impact of burning reduced the overall quantity of organic material in the assemblage and might be reflected in the general reduction of Micropteroptera bone over time indicated in table 27. The *P. orientalis* results reflected a different pattern of burning per body part than the rest of the assemblage. This suggests that it was treated differently to other taxa in relation to fire.

9. CONJOINS

Conjoin analyses seek to identify artefacts that were broken in the past. The results directly reflect post-depositional vertical (or horizontal) redistribution of the artefacts and therefore contribute to determining the nature of site stability.

Systematic conjoin analyses were undertaken as part of previous analyses (Leavesley and Allen 1998) and were not repeated as part of this analysis. However, a variety of conjoins was identified in the assemblage and is listed in table 62.

Table 62: Conjoins identified in the Buang Merabak assemblage

Test pit	**Id. #**	**Spit**	**Taxon**	**Element**	**Comment**
TP1A	N/A	Unit IV	*P. orientalis*	Incisor	Transverse split
TP1A	5278	4	Reptilia	Mandibles	Symmetrical pair, conjoin at the symphysis
TP1A	N/A	6	*P. orientalis*	Femur	Almost perpendicular, rough & calcified fracture surface
TP1B	3382	11	*P. orientalis*	Humerus	Almost perpendicular, calcified fracture surface
TP1A	N/A	12	*P. orientalis*	Femur	Almost perpendicular, calcified fracture surface
TP1B	N/A	13	*P. orientalis*	Femur	Almost perpendicular, calcified fracture surface
TP1B	4223-4223	14	*P. orientalis*	Femur	Spiral, calcified fracture surface
TP1B	N/A	31	Pteropus	Humerus	Stepped, calcified fracture surface
TP1A	N/A	8	Mammal	Long bone	Calcified to a rock (see pic)
TP1B	N/A	9	Stone	N/A	Two parts of a grinding stone (see pic)
Calcified conjoins					
TP1B	889	6	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1A	2284	7	*P. orientalis*	Mandible	Molar erupted and calcified obliquely in its

					alveola
TP1A	2358	8	*P. orientalis*	Mandible	Erupted M1 is calcified to a conglomerate attached to the I1
TP1A	N/A	8	Mammal	Long bone	Transverse split, clearly detached & recalcified adjacent to the matching fractures
TP1B	2330	8	Unknown	Unknown	Multiple distinctly detached fragments recalcified to the side of a mandible in close proximity to each other
TP1A	2349	8	*P. orientalis*	Mandible	Molar split and calcified obliquely in its alveola
TP1B	912	10	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1A	2628	10	*P. orientalis*	Mandible	Incisor erupted and calcified adjacent to its alveola
TP1B	937	11	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1A	N/A	12	Mammal	Long bone	Transverse split, clearly detached & recalcified adjacent to the matching fractures
TP1B	943	12	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	965	13	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	975	13	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	4180	13	*P. orientalis*	Vertebrae	The transverse processes are detached from the centrum and recalcified with a clear gap between the fractures
TP1B	1594	14	*P. orientalis*	Mandible	Vertical ramus is detached from the M5 alveola but calcified in place
TP1B	4470	14	*P. orientalis*	Mandible	Alveola clearly detached from the ramus of dentary and calcified ajar to the fracture
TP1B	4466	14	Mammal	Long bone	Crushed and re-calcified
TP1B	4667	16	*P. orientalis*	Mandible	Mandible split with the fragment calcified adjacent to the fracture
TP1B	1020	17	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1767	17	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	4705	17	Mammal	Long bone	Transverse split, clearly detached & recalcified adjacent to the matching fractures
TP1B	1688	18	*P. orientalis*	Mandible	Ramus of dentary detached from alveola and calcified ajar to the fracture
TP1B	1072	22	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1773	22	Reptilia	Vertebrae	Two articulated vertebrae calcified together and two more vertebrae calcified irregularly
TP1A	N/A	23	Mammal	Long bone	Transverse split, clearly detached & recalcified adjacent to the matching fractures
TP1B	1077	23	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1774	23	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1774	23	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	4857	24	Mammal	Long bone	Transverse split, clearly detached & recalcified adjacent to the matching fractures
TP1B	1124	25	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1149	26	Reptilia	Vertebrae	Five articulated vertebrae calcified together
TP1B	1150	26	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1195	28	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1197	28	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1228	29	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1229	29	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1230	29	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1245	30	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1249	30	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1272	31	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1285	32	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1296	33	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1324	34	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1363	36	Reptilia	Vertebrae	Two articulated vertebrae calcified together
TP1B	1368	37	Reptilia	Vertebrae	Two articulated vertebrae calcified together

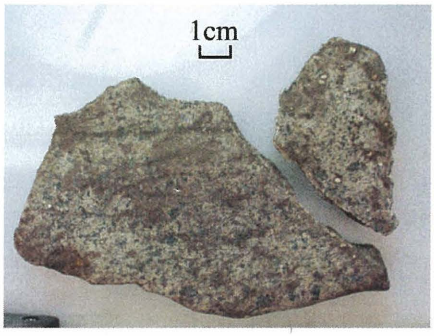

Figure 17: Two conjoining fragments of a grindstone both from TP1B, spit 9.

The assemblage contains two types of conjoin. The first are two specimens of bone or stone that were broken in the past and were refitted (see figure 17). The second are described by Leavesley and Allen (1998) as sets of bones that were broken or separated in the past but were not disarticulated and subsequently were calcified *in situ* (see figure 18).

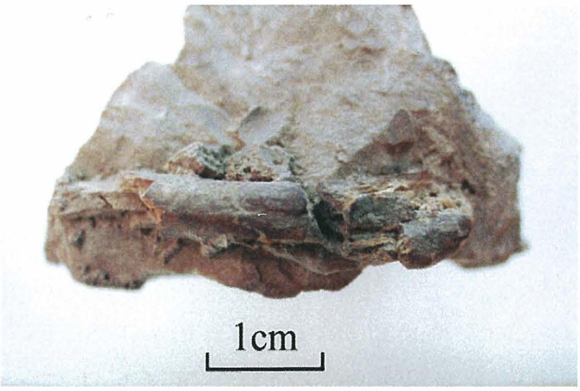

Figure 18: Two conjoining long bone specimens from TP1A, Spit 8 calcified to a stone. Note the calcium carbonate on the fracture surface.

While this analysis was not systematic it identified 55 conjoins. The conjoining specimens are from all across the depth of deposit and suggest a degree of stability in the deposit.

10. CONCLUSION

The site preservation was high, because the sediment matrix was relatively alkaline, reflected in the large quantity of fragile bones. Elements within the assemblage reflect a number of attributes indicative of human behaviour. The deposit is associated with a shell midden that contains a quantity of stone artefacts. The sediment contains a relatively high density of bone that is considered uncommon at natural bone deposits. The assemblage also exhibits low levels of burnt bone that is commonly associated with the processing and consumption of prey by humans. Interestingly, the evidence of burning increases over time while the quantity of very small bone decreases allowing for the possibility that the former has a direct relationship on the latter. The breakage pattern analysis suggests that a third of the fractures are the result of human processing and consumption. The *D. anderseni* and other Megapteroptera were an important part of the diet in Units 2, 3 and 4 and were gradually replaced by the *P. orientalis* in Units 1, 2 and 3. The large lizards, *Varanus* sp. *Eugongylus* sp. and *D. anderseni* were present in Unit 4.

The fracture analysis suggests that 20-25% of all *P. orientalis* fractures in Units 1, 2 and 3 occurred in the process of capture and consumption. For *D. anderseni*, between 30% and 45% of fractures in Units 2, 3 and 4 and for Megatperoptera 20% of Units 2, 3 and 4 and 10% of Unit fractures occurred in the process of capture and consumption. For Reptilia, 12% in Unit 4 occurred in the process of capture and consumption and none of the Unit 3 fractures. This suggests that Reptilia were part of the diet in Unit 4 but not in Unit 3.

The *P. orientalis* mortality profile data support the human predation model because the large number of young animals present is consistent with the argument that younger animals were generally easier to hunt. Finally, there were few bones that exhibit cut marks likely reflecting the fact that the assemblage predominantly contains taxa that can be relatively easily disarticulated without substantial effort.

The two major taxa in the assemblage, *P. orientalis* and *Dobsonia* sp., were deposited in the site primarily as part of the process of consumption and form the basis for the interpretations in the following Chapters.

Chapter 6
The Pre-Last Glacial Maximum Pleistocene Resource Use, Hunting Strategies, Land Use and Mobility

1. INTRODUCTION

This Chapter describes notions of colonization and the subsequent adaptations to the New Ireland environment. Adaptations are interpreted in the context of resource use, hunting, land use and mobility in New Ireland as interpreted from the Buang Merabak Units 4 and 3 faunal assemblages. Unit 4 spans the period from 39,500 bp to 27,000 bp (table 11) and contains 10,575 NISP of bone, equivalent to 16,745 per m^3 (table 14). Unit 3 spans the period 22,000 bp to 20,000 bp (table 11) and contains 5791 NISP of bone, equivalent to 11,424 per m^3 (table 14).

2. RESOURCE USE

The importance of the efficient use of resources during Pleistocene New Ireland was well attested (Enright and Gosden 1992:175) for two reasons. First, the New Ireland terrestrial taxa were relatively depauperate compared to other islands, placing extra emphasis on human adaptive strategies. And secondly, rainforests were difficult environments to live in because although they have a high biomass when viewed as a total ecosystem (Foley 1987:97), the packages into which this biomass is divided are generally small or dispersed and not easily exploited by humans (Enright and Gosden 1992:172). Therefore tropical rainforests are seen as difficult environments within which to subsist.

Using the faunal analysis, resource use can be described in two ways. First, what animals were selected by the human hunters? And secondly, did they employ generalist or specialist prey selection strategies? The former was primarily dealt with in Chapter 4. The latter is determined by comparing the relative quantity of each taxa per Unit to determine if the human diet is skewed towards any particular taxa.

2.2 Unit 4

In Unit 4 the range of taxa was relatively narrow. *P. orientalis* was absent and the *Dobsonia* sp., most likely the *D. anderseni,* was the dominant prey taxa (tables 28 to 32). Large lizards have been demonstrated to be important in the lower two units (Leavesley and Allen 1998:76; Spriggs 2000:290) with the large Scinidae lizards, *Eugongylus* sp. and the *Varanus indicus,* (see tables 46 and 37) present in greater numbers in Unit 4 than any of the following Units.

The dominance of the Megapteroptera, specifically the *Dobsonia* sp., suggested that the earliest humans at Buang Merabak participated in specialist *Dobsonia* sp. hunting and consumption. This may indeed be driven by the fact that there was few other prey taxa in New Ireland during this period though it does not make the human focus on *Dobsonia* sp. any less specialised.

2.2.2 Inter-Taxa Comparison

The comparison of the dietary contribution of meat from different taxa to the human diet is a complicated issue. The meat of different animals has different ratios of vitamins and minerals reflecting their respective diets and therefore has different dietary value for humans. The standardization of dietary value is therefore an extremely complex process to disentangle. Meat weight values are highly contingent upon a variety of factors including environment, animal age, disease and season of capture etc. (Smith 1985:114-132). The environment in general provides the context within which the taxa live. If the environment provides plenty of food then the prey will have a greater meat weight. Animal body size changes with age. Commonly, mature adults are the largest while both younger and older animals carry less weight. Disease can cause animals to change and commonly lose weight. Seasonal cycles influence animals because they provide different resources in different quantities at different times. These factors have an appreciable influence on animal weight. In any given population they will influence different individuals in different ways and therefore the calculation of an average meat weight per taxa is going to have to be interpreted as though it has a large standard deviation. Meat weight value is a useful indicator of the dietary contribution of different animals because the calculations require the least number of assumptions. However, as it does not engage with the complex issues described above, it can only be considered as indicative rather than definitive.

The average animal weight for the mammals presented in table 63 is from Flannery (1995). Kirch and Yen (1982:304) suggest that shell weight contributes 80% of the total animal weight while mammal skeletal weight equals 6.35% of total animal weight (Kirch and Yen 1982:304-305). Data from Pasveer (2003:212) indicate an average of 7.16% skeletal weight per animal for a suite of fauna from the Bird's Head. More specifically for the family Pteropodidae, for an individual with an average total body weight of 400 gms, the skeleton accounts for 8% and the remaining 92% represents meat weight (Pasveer 2003:212). Shell meat weight is derived from data presented by Miller et al. (1997) and Smith (1985:489). Smith (1985:489) listed 31 shellfish species with meat weights ranging from 0.001 gm to 0.15 gm averaging 0.01 gm. For the purposes of table 63 a value of between 1 gm and 3 gm was used as the meat weight for the shell taxa in an attempt not to under estimate them and to account for the variety of shell sizes in the absence of explicit values. The MNI values in table 63 were extrapolated from Balean's (1989: Appendix 1) data recorded from SQ2B, SE quadrant (Rosenfeld 1997). Balean (1989) selected the SE quadrant for analysis because it contained the most archaeological material (Balean 1989:7) and therefore represents the maximum density in SQ2B. Accepting the limitations described above the data provided in table 63 are considered as an estimate rather than definitive values.

Table 63: Taxa (MNI/taxa from Balean 1989: Appendix 1) by meat weight in SQ 2B Units 5 and 6 (units after Leavesley and Allen (1998:65). *Dobsonia* sp. (tables 31 and 32) and *Pteropus* sp. (table 33) data from this analysis for Unit 4. Mammal meat weight is calculated at 90% of total body weight. Shellfish meat weight is estimated on the basis of Miller et al. (1997) and (Smith 1985). ind= individual animal.

Taxa	**MNI**	**Ave. total animal wt. (gm)**	**Meat wt./ ind. (gm)**	**Total mt. wt. (gm)**	**Total (gm)**
Megapteroptera					
Pteropus sp.	2	1000	900	1800	
Dobsonia sp.	22	200	180	3960	*5760*
Shell					
Turbo sp.	61	N/A	3	183	
Chiton	341	N/A	1	341	
Cypraea sp.	4?	N/A	1	4	
Trochus sp.	24	N/A	3	72	
Nerita sp.	432	N/A	1	432	
Tectarius sp.	32	N/A	1	32	*1064*

The meat weight results suggest that the Unit 4 faunal assemblage contained *Dobsonia* sp. rather than shellfish. *Dobsonia* sp. inhabits the rainforest while shellfish inhabit the littoral zone. More meat was procured from the rainforests than the littoral suggesting that the rainforests were of greater importance in Unit 4 than littoral zone.

The results in tables 20 and 21 list the taxa present in Unit 3. The Megapteroptera were 91% of the NISP and 73% by weight of post-cranial elements and are only a couple of points down from Unit 4. The family Reptilia was 4% of Unit 3 NISP and 11% by weight. This reflects a marginal increase in their relative quantity compared to Unit 4. The *P. orientalis* appears in the assemblage for the first time and is 2% of NISP and 13% of weight of the post-cranial assemblage.

2.3 Unit 3

Unit 3 exhibited the same basic pattern as Unit 4 indicating the specialised predation and consumption of *Dobsonia* species. While *Dobsonia* sp. were still the dominant prey taxa the appearance of the *P. orientalis* was particularly important because it becomes the dominant prey taxa in Unit 2 (see tables 18 and 19). What follows is an investigation into the impact of the *P. orientalis* on human consumption patterns beginning with a discussion about its human translocation into New Ireland.

What impact did the introduction of the P. orientalis into the diet have on the consumption of the pre-existing fauna?

Irrespective of how it arrived into New Ireland (see Chapter 2) the impact of *P. orientalis* (see Chapter 2) on human prey selection and protein consumption is investigated through a comparison of the contribution of different taxa in Units 3 and 4. The quantity of *P. orientalis* in the assemblage indicates that it had a major impact on the human diet. Prior to its introduction at 20,000 bp the *Dobsonia* sp. was the dominant taxon. After the introduction of *P. orientalis* it was the dominant taxon until the end of the most recent period of occupation at 1800 bp (1300 Cal. BP).

The impact of the introduction of a new prey taxon into the diet had implications for the way pre-existing prey resources were utilized. It can be reflected in both the intensity of predation on the new taxon and indirect consequences on the pre-existing prey taxa and both were investigated below. The MNI, NISP and average fragment size per unit were utilized as representing the quantitative contribution of the taxa to the human diet over time. It included an analysis of element presence/absence and bone fracture data. For example, if there is a greater ratio of green breaks to dry breaks after the introduction of the *P. orientalis*, then this is interpreted as an increase in intensity of utilisation.

The results in tables 20 and 21 indicate that after the introduction of the *P. orientalis* the relative contribution of the *Dobsonia* sp. to the human diet reduces by both NISP and weight. However, these data do not indicate whether the intensity of consumption also reduced in line with the quantity of the taxa in the assemblage. For instance, it might be plausible that the quantity of *Dobsonia* sp. within the assemblage reduced but the intensity of consumption remained the same or increased. The consumption of the *Dobsonia* sp. was investigated through an analysis of the element and body part distribution between Units 4 and 3.

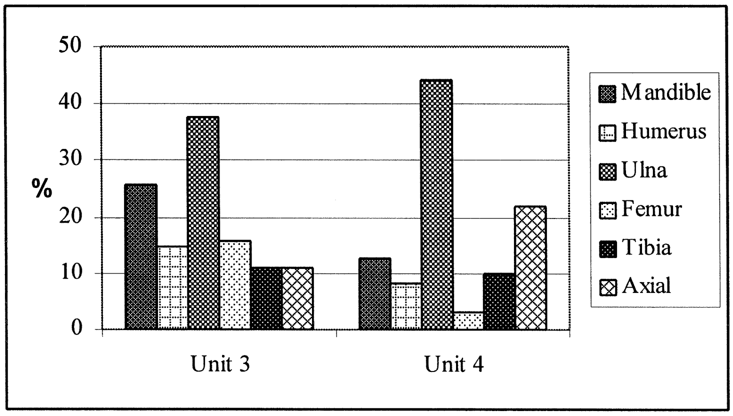

Figure 19: Buang Merabak TP1B Megapteroptera and *Dobsonia* sp. percentage of elements per Unit (table 40).

The results in Figure 19 indicate an over-abundance of Megapteroptera ulna elements, relative to other elements, in both Units 4 and 3. This may reflect the very low levels of meat associated with Chiroptera fore-limbs (wings) compared to other mammals. Chiroptera have disproportionately large fore-limbs to facilitate flight. The wings themselves consist of a thin and fragile skin membrane devoid of any substantial nutritional value. Unit 4 has a lower percentage of non-ulnas to ulna elements than does Unit 3 suggesting Unit 4 has more wings to bodies than Unit 3. If the ratio of body parts to MNI is taken as a proxy for consumption of Megapteroptera then Unit 4 exhibits evidence of more intensive consumption than does Unit 3.

Figure 19 also indicates a shift from a greater percentage of axial specimens in Unit 4 to a greater percentage of humeri and mandibles in Unit 3. Assuming that presence in the assemblage indicates non-consumption, the results suggest a shift in the nature of consumption of the taxa. Unit 4 indicates more intensive consumption of all but the ulna and axial categories while Unit 3 indicates relatively less intensive consumption of meat associated with the humeri, mandibles and femora.

2.3.2 Resource Use - Summary

In Chapter 4 the fracture pattern results were interpreted to differentiate between cultural and natural formation processes. Here the relative quantity of green fractures was interpreted as representing intensity of skeleton reduction as a reflection of human consumption behaviour in order to address the issue of whether the nature of *Dobsonia* sp. consumption changes after the introduction of the *P. orientalis* into the diet. This method is based on the assumption that increased consumption intensity equates with increased breakage of the animals consumed. The results in table 52 indicate a slightly reduced percentage of 'green' to total fractures in Unit 3 than Unit 4. The value represents all taxa interpreted here as a general trend towards the less intensive breakage of specimens in Unit 3 than Unit 4.

A comparison between *D. anderseni* and the family Pteropodidae indicates there was a change between Units 4 and 3. Assuming the percentage of green to total fractures was indicative of the level of prey carcass butchering, as part of consumption process, the Units can be compared in terms of intensity of butchering. In table 52 the percentage of green to total fractures for the Megapteroptera was consistently around 18-19% in both Units. This contrasts with *D. anderseni* which has a reduction from 45% in Unit 4, to 30% in Unit 3 indicating that overall Megapteroptera were not fractured during consumption as intensively as *D. anderseni* and were therefore relatively less important to the diet.

A closer look at *D. anderseni* in table 52 indicated a general reduction in the percentage of green fractures from Unit 4 to Unit 3. It was interpreted as indicative of a relative reduction in the intensity of butchering of *D. anderseni* in Unit 3. Unit 3 corresponds with the introduction of the *P. orientalis* into the diet and supports the proposition that the human utilisation of the *D. anderseni* changed after the appearance of the *P. orientalis*.

The overall NISP and weight of *Dobsonia* sp. and Megapteroptera dropped after the introduction of the *P. orientalis* (see tables 20 to 23). The percentage NISP of elements/body parts indicate a decrease in the intensity of the reduction of the *Dobsonia* sp. and Megapteroptera after the introduction of the *P. orientalis* while the percentage of 'green' fractures to total fractures is marginally lower for all taxa (see table 52). Although the percentage of green fractures to total fractures remains consistent between Units 4 and 3 for Megapteroptera and *D. anderseni* the results indicate a reduction in butchering intensity in Unit 3. Collectively the results indicate an important change in the manner in which Megapteroptera and *Dobsonia* sp. taxa were consumed after the introduction of the *P. orientalis* into New Ireland. The data suggest both a reduction in the relative quantity of Megapteroptera and *Dobsonia* sp. in the diet and a reduction in the intensity of consumption as an indication of changing resource use patterns.

The body part and element distribution of the Megapteroptera and *Dobsonia* sp. indicate a change from Unit 4 to Unit 3. Unit 4 had an over abundance of Ulna specimens to other element and body part categories suggesting that the latter were more intensively consumed than the former. Unit 3 contained a greater percentage of mandibles and humeri than Unit 4. This suggests that these elements were less intensively consumed in Unit 3 than in Unit 4. Collectively the fracture analysis and body part/element distribution suggest a less intensive reduction of the Megapteroptera and Dobsonia sp. after the appearance of *P. orientalis* in Unit 3 than in Unit 4.

3. HUNTING STRATEGIES

Hunting strategies represent a cost effective way to collect protein. Given the importance of protein in the human diet and the relative scarcity of protein resources in New Ireland, hunting strategies had a significant impact on human land use and mobility.

3.2 Unit 4

Tables 22 and 23 indicate that Unit 4 had a much greater percentage of *Dobsonia* sp. than any other Chiroptera. Chiroptera can be hunted by two very different strategies. Chiroptera can be hunted while in flight or while they are feeding in trees. They are particularly difficult to catch on the wing (in flight) without the aid of a projectile that can be propelled accurately. Alternatively, they can be captured in relatively greater quantities while roosting. A comparison of the Unit 4 data in tables 41 to 44 indicates that the dominant *Dobsonia* sp. taxon was *D. anderseni* that roosts in large cave colonies (see Chapter 2). The hunting ethnography in Chapter 2 suggests that in the pursuit of Megapteroptera the highest yields can be obtained by hunting them at their cave roosting sites such as at Buang Merabak (see Chapter 3). The hunting strategy may be as simple as entering the cave roosting site with a tree branch and bludgeoning the prey. This strategy requires minimal technology and could be undertaken by a lone hunter. Alternatively, a greater yield might be obtained if the strategy was expanded by first, building barricades over all but one exit to the cave, secondly, lighting a fire in the roosting chamber so as to encourage the colony to leave the cave via the only passage that remains open and thirdly, ambushing the individual Chiroptera as they attempted to leave the cave via the only remaining exit. This strategy would be most successful with a small group of people with knowledge of Chiroptera ecology.

The combination of the ecological characteristics of *D. anderseni* and the advantages they provide for the hunter over other potential prey strongly suggests that Buang Merabak is an ideal bat hunting location. The most parsimonious explanation for the presence of large numbers of *Dobsonia* sp. in the assemblage and in particular, *D. anderseni,* in Unit 4, is that they were hunted while roosting rather than on the wing. This method of capture is the most likely because it maximises the return and reduces the risk of failure.

3.3 Unit 3

Unit 3 contains no evidence to suggest that Chiroptera hunting altered from that described above for Unit 4. The inclusion of the *P. orientalis* reflects a marginal increase of the capture of rainforest prey taxa. The strategies employed in the capture *P. orientalis* will be discussed in association with Unit 2 where it is the dominant prey taxa and therefore has the greatest impact on hunting strategies.

3.3.2 Hunting Strategies - Summary

Both Units 3 and 4 suggest hunting of *Dobsonia* sp. occurred at the cave site utilising techniques requiring small groups of people and knowledge of the prey's ecology but little technology. The presence of Rodentia, Reptilia and *P. orientalis* reflect the limited use of the rainforest as a hunting ground in relation to the food consumed at the cave.

4. LAND USE

Land use can be conceptualized on a variety of scales including the site, site hinterland, island or archipelago etc. and must therefore be defined. One of the limitations of this kind of arbitrary division is that care must be taken to ensure that the scale of interpretation is comparable with the spatial zone in question. In the context of this dissertation land use is divided into two parts that equate with on site and off site. The former reflects activities that occurred at the site and has a geographic boundary. The latter reflects activities that occurred away from the site but were informed by what was deposited at the site and was therefore bounded by behaviour rather than geography. While a wide variety of activities doubtless occurred in relation to the site, the following discussion confines itself to hunting and consumption of terrestrial prey taxa.

4.2 Unit 4

4.2.2 Site Use (On Site)

The Unit 4 bone assemblage was dominated by Megapteroptera and complemented in <1% of the unit assemblage by the family Reptilia. Of the Megapteroptera, 2.4-6.6 % of the bone represents taxa that do not commonly occupy caves while the remaining 86.61%-88% were *Dobsonia* sp. that do commonly occupy caves (see table 23). As described in Chapter 3, *Dobsonia* sp. most likely reflects hunting at the cave site. If the quantity of *Dobsonia* sp. in the assemblage reflects their relative importance in the human diet at the site, it indicates that a relatively high proportion of time was allocated to the pursuit of on site activities of hunting followed by consumption.

The spatial proximity between the location of the archaeological assemblage and the bat roost suggests that the cave had two purposes. The predation of the Megapteroptera population occurred in association with the third chamber and the consumption of the catch occurred in the mouth of the first chamber. In terms of Binford's (1980) classifications the results can be interpreted in two ways. First, the third chamber was a hunting location at which extractive tasks were exclusively carried out (Binford 1980:9). The catch was subsequently transported the short distance to the mouth of the first chamber where consumption occurred. In terms of land use the crucial factor was whether the two activities were clearly delineated by either the division of labour and/or distance between activity areas. Alternatively, the entire cave might be interpreted as the site with two distinct activity areas. The cave was both a resource patch and a consumption site. The latter interpretation is preferred because, as described in Chapter 2, the third chamber was within 30 m of the first chamber and therefore did not require the division of labour to exploit the resource or represent a great enough distance to distinguish between activities as separate locations. Binford (1980:9) characterised foragers as people with high residential mobility between high density resource patches.

4.2.3 Land Use (Off Site)

Off site land use can be inferred from the assemblage using behavioural ecological theory because different taxa reflect the environmental zones to which the hunters went to capture prey (Dwyer and Minnegal 1991:193). The characteristics of the ecological niche specific to each of the respective prey taxa indicate something about their predation, consumption and time scheduling for associated activities.

As described above the *Dobsonia* sp. represent 86-88% (see table 23) of the assemblage in Unit 4 and reflect on site behaviour leaving the remaining 12-14% potentially reflecting off-site behaviour. If the percentage of fauna broadly reflects the time allocated to the pursuit of a prey taxa, then the remaining 13% of procurement time was spent in the pursuit of the forest dwelling families Pteropodidae, Scinidae, Varanidae and Muridae. Pteropodidae inhabit the forest canopy and have the ability to roost in colonies or as individuals and are commonly hunted with the use of projectiles. Scinidae, Varanidae and Muridae do not congregate in family groups and inhabit the undergrowth and trees of the rainforest. In addition, Varanidae have a tendency to prefer mangrove environments. The broad distribution this taxa across the rainforest indicates generalist rainforest foraging practices.

The Unit 4 results support the suggestion that a majority of hunting time in relation to consumption was spent in the cave and represents both the activities of hunting and consumption. From this site a minority of hunting time was spent in rainforest.

4.3 Unit 3

The Unit 3 land use follows the patterns described for Unit 4. On site behaviour reflects *Dobsonia* sp. consumption while off site land use begins to change with the introduction of the *P. orientalis* in the diet.

4.3.2 Site Use (On Site)

The Unit 3 assemblage was dominated by *Dobsonia* sp. and complemented by the family Reptilia (4% of NISP and 9% of weight as seen in table 21). As described above, the *Dobsonia* sp. indicates that a majority of time was spent engaged in predation of taxa found at the cave site and their consumption as described above for Unit 4.

4.3.3 Land Use (Off Site)

Unit 3 contains the same rainforest taxa as Unit 4 (families: Pteropodidae, Scinidae, Varanidae and Muridae) with the addition of the *P. orientalis.* The presence of these taxa has implications for land use. The table 61 results were similar to that described for Unit 4 (above) and suggest an emphasis on the cave habitat fauna. However, there are a number of important issues to take into consideration. First, the post-cranial values for cave inhabitants are zero because Megapteroptera post-cranial elements are difficult to distinguish between species on morphological grounds alone. Therefore, it is difficult to distinguish which elements are from taxa that inhabit caves and those which do not. Consequently, the values are unrealistically skewed away from cave inhabitants. Secondly, the different average body size of each of the taxa has implications for interpretation. The primary cave inhabitant was the Megapteroptera weighing in the order of 250 gm. per adult male while the primary forest habitat species was the *P. orientalis* weighing in the order of 2 kg per adult male (Flannery 1995). A smaller number of larger animals will be over-emphasised by weight and under-emphasised by NISP. Furthermore, if we turn to notions of hunting and compare expeditions on the basis of what might constitute success there is potential for a similar difference between weight and NISP. *P. orientalis* forage primarily as individuals and occasionally as small groups. The product of a successful hunting expedition might be the capture of a single individual because they are large enough to provide the basis of a meal. *Dobsonia* sp., although smaller in size, congregate in larger numbers when roosting during the day in caves. A successful hunting expedition might entail the capture of multiple *Dobsonia* sp.

individuals. However, as these scenarios cannot be calculated statistically it is difficult to build them into the equation. With the complexity of prey behaviour taken into consideration, table 64 indicates a greater emphasis on taxa that represent the use of the cave as a hunting locale than the bush.

Table 64: Percentage of all taxa in Unit 3 by habitat and body part from tables 20 and 21.

	Bush		**Cave**		**Bush/cave**	
	NISP	**Wt.**	**NISP**	**Wt.**	**NISP**	**Wt.**
Cranial	22.92	66.57	68.75	32	8.33	1.4
Post-cranial	8.84	26.65	0	0	91.16	73.43

Table 65: *Phalanger orientalis* and *Dobsonia anderseni* MNIs per Unit from tables 38 and 41.

Taxa	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**
P. orientalis	19	79	4	0
D. anderseni	0	13	13	19

The results in tables 64 and 65 in conjunction with the NISP and weight data in table 63, suggest that the *P. orientalis,* while represented by a relatively low MNI value, was an important part of the Unit 3 assemblage and perhaps equal to *Dobsonia* sp. in terms of its importance to the human diet. The introduction of *P. orientalis* represents an increase in the use of rainforest habitat for hunting compared to the situation in Unit 4.

4.4 Land Use - Summary

The *Dobsonia* sp. were the prime resource utilized in Unit 4 and 3. They indicate that caves were used for hunting and consumption. In terms of the protein consumed at Buang Merabak a vast proportion came from the cave itself and a smaller amount was brought to the site from the rainforest hinterland.

The introduction of *P. orientalis* into the human diet in Unit 3 marks a change in land use in relation to consumption behaviour at Buang Merabak. It indicates that, while resources are still being acquired at the site itself, they are supplemented to a limited extent by resources obtained in the rainforest as well.

5. MOBILITY

It has been suggested that the first inhabitants of New Ireland were small groups of mobile hunter/gatherers (Allen 2000:145) and in this context mobility can be considered in two ways. The first perspective, in the absence of multiple sites from which to draw evidence, was to consider the Buang Merabak assemblage as a sample of the sites in the region. Matenkupkum was the only other comparable site and had a generally similar suite of fauna (Leavesley and Allen 1998:78), although it had a reduced quantity in its basal layer (Robertson 1986:76). An alternative perspective might be that the Buang Merabak assemblage is not typical and therefore it reflects mobility only as it pertains to the direct use of the cave itself.

Mobility was reflected by what was brought to the site from elsewhere. Notions of human mobility reflect a wide range of factors including the human requirement for social interaction and resource acquisition. What follows is an investigation into human mobility in which resource acquisition was considered within an environmental framework reflecting the distribution and nature of the resources. Binford (1980) identifies two sets of criteria that inform the nature of mobility and distinguish between foragers and collectors. Based on micro-economic principles, resource density and distribution were used to model relative degrees of base camp and hunting mobility. Forager interaction with resources was dependant upon resource distribution. Low density homogenous distribution of resources resulted in longer stays at base camps (low base camp mobility) and more hunting trips (high hunting mobility) with slower movement between base camps. Alternatively, high density resource patches with low density resources between them resulted in shorter stays at base camps (high base camp mobility) and fewer hunting trips (low hunting mobility), with faster movement between camps. The density and scarcity of resources reflected the degree to which hunter/gatherers were dependant upon particular locales or resources. Collectors were discernible from foragers on the basis of either storage of food or logistical organisation of activities. Binford (1980:9) provided a further contingency in relation to the scarcity of resources. In a setting with limited loci of available and critical resource, residential mobility may be tethered around a series of restricted locations.

5.2 Unit 4

As described above, in relation to food consumption in Unit 4 at Buang Merabak human behaviour was focussed on the predation of cave dwelling Chiroptera. When hunter/gatherers found themselves within the hinterland of the site they went to the site primarily for the purpose of hunting Megapteroptera. The hunting and consumption of the *Dobsonia* sp. at the site at which they are caught equate with consumption at the kill site. It is also consistent with low transport costs for Chiroptera and relatively higher transport costs for the smaller quantity of other non-cave dwelling taxa, such as the families Aves and Reptilia that make up a small proportion of the assemblage.

The *Dobsonia* sp. represents a high density resource patch (Binford 1980). The high quantity of *Dobsonia* sp. in Unit 4 indicates that high density resource patches were targeted by New Ireland's Pleistocene hunters. The ecology of *Dobsonia* sp. roosting in colonies on a daily basis indicates they are a high density resource. The quantity of *Dobsonia* sp. represented in tables 22-23 and 41-44 indicate that they were the most prevalent prey taxa in the Unit 4 assemblage. However, to demonstrate tethering the archaeological record must indicate that the same pattern occurs across the landscape inevitably requiring evidence from more than one site and therefore tethering is not demonstrated by the present evidence. Future research may reverse this conclusion if more sites demonstrate the same pattern as described above. Within the Binford (1980) interpretative framework the result is a mobility pattern characterised by shorter stays at base camps, fewer hunting trips and faster movement between base camps.

Cultural ecology theory suggests that the decision to move from, and/or to, any given resource-patch location was made on the basis of energy expenditure versus perceived potential for energy gain. Once the resource, that is the *Dobsonia* sp. colony, was diminished to a point at which the capture of the remaining Chiroptera required more energy expenditure than energy gained from their capture, then the next resource patch, that is, the next *Dobsonia* sp. colony, was more attractive than remaining at the site. At this point the hunters moved rapidly to the next resource patch leaving the remnant colony for more economical prey elsewhere.

If the Buang Merabak assemblage was a typical representation of pre-27,000 bp behaviour in New Ireland and the *Dobsonia* sp. was the mainstay of terrestrially based protein procurement, then the caves were important nodes on the landscape because they represented a series of high density resource patches in a relatively depauperate rainforest. The hunters moved between caves in order to exploit the resident *Dobsonia* sp. populations. An unknowable percentage of the bat colonies were captured by human hunters and the remaining animals, were frightened off unlikely to return immediately to the cave. Therefore, each cave was only exploited once before the hunters moved on to the next resource patch.

5.3 Unit 3

Unit 3 contained a high proportion of *Dobsonia* sp. and was supplemented with *P. orientalis.* The presence of *P. orientalis* had some interesting implications for mobility in the hinterland of the site. First, it reflected an increase in the amount of time and resources spent in the forest as opposed to the cave (as described above). The predation of *P. orientalis* may require tracking, and/or chase, trapping or ambush (Bulmer 1968). All of these methods required an intimate knowledge of the forest environment that in turn necessitated time spent in the forest. The activities associated with *P. orientalis* hunting occurred within the forest and therefore mobility through the forest was relatively slower.

Secondly, the increase in forest habitat prey in the diet had implications for hunter/gatherer division of activities and use of space. The consumption of the *Dobsonia* sp. at Buang Merabak indicates the site was used as both a kill site and consumption site. The consumption of *P. orientalis* at Buang Merabak represents a behavioural and perhaps conceptual or cognitive division between activity areas. Activities were defined by episodes of relocation. The transportation of *P. orientalis* carcasses to Buang Merabak prior to consumption reflects a division between hunting and consumption sites. While *P. orientalis* was present in Unit 3 it was not the dominant prey taxa until Unit 2.

Dobsonia sp. dominated the assemblage indicating more of the same high base camp mobility between the cave sites, that represent nodes on the landscape that contain high density resources patches.

5.4 Mobility - Summary

Within this basic framework the presence of *P. orientalis* represents a dispersed resource that reduces the intensity of mobility between the resource patches. They also reduce the hunters' dependence upon the high density resource patches and in turn diminish the impact of the tethering effect with the result of increasing the flexibility of land use. Additionally, *P. orientalis* reflects behaviour beyond the scope of Binford's foragers and incorporates crucial aspects of collectors through the spatial division of activities.

5. CONCLUSION

The Unit 4 faunal assemblage was characterised by large quantities of *Dobsonia* sp. cave dwelling bats from the beginning of its use by humans. While Buang Merabak was near the coast the early utilisation of Chiroptera that were also available at inland sites suggests that New Ireland's inhabitants were aware of the availability of forest resources immediately upon colonization. This is interpreted as suggesting a greater emphasis on land based rather than littoral resources. While Megapteroptera can be caught on the wing they were easier to catch in the enclosed areas that were their cave roosts. When humans were in proximity to the site they spent some of their time collecting other fauna such as Reptilia, Rodentia, Aves and shellfish and a larger proportion of their hunting time was spent at the cave itself. This in turn suggests that, at least at a local scale, the cave was an important resource patch.

The Unit 3 faunal assemblage was characterised by large quantities of *Dobsonia* sp. and a smaller quantity of *P. orientalis*. The *Dobsonia* sp. was captured in the enclosed third chamber of the Buang Merabak that was their roost. The *P. orientalis* were captured in the surrounding rainforest hinterland. In relation to terrestrial protein consumption at Buang Merabak, the human hunters divided their hunting time between the *P. orientalis,* Rodentia, Reptilia and Aves of the forest and the *Dobsonia* sp. at the site itself.

Chapter 7

The Pleistocene/Holocene Transition and Late-Holocene

1. INTRODUCTION

This Chapter describes notions of resource use, hunting, land use and mobility on the basis of the Buang Merabak Units 2 and 1 faunal assemblages. Unit 2 spans the Pleistocene/Holocene transition period from 12,000 bp to 7000 bp (see table 13) and contains 9423 NISP of bone, equivalent to 19,815 per m^3 (see table 14). Unit 1 spans the period from 3500 bp to 1800 bp (see table 13) and contains 2799 NISP of bone, equivalent to 8836 per m^3 (see table 14).

The Unit 1 fauna reflects a different subsistence strategy at the site than the fauna of Units 2, 3 and 4. Unit 1 was contemporary with Late-Lapita represented by a number of sites reflecting evidence of agriculture in the region (Spriggs 1997). The nearest Late-Lapita site to Buang Merabak was at the nearby Lasigi village (Golson 1991). Lapita reflects agriculture including animal husbandry and relatively sedentary populations (Spriggs 1997). The temporal overlap between Buang Merabak representing hunter/gatherers on one hand and Lasigi representing agriculturalists on the other provides a rare opportunity to investigate the impact of agriculture, brought to New Ireland by Austronesian speakers, on the pre-existing hunter/gatherer Papuan speaking populations. In addition to investigating the nature of resource use, hunting, land use and mobility the impact of the introduction of agriculture will be considered. A comparison between Units 2 and 1 as representative of hunting behaviour both before and after the introduction of agriculture was undertaken to determine whether hunting behaviour changed at Buang Merabak.

2. RESOURCE USE

Resource use refers to the quality and quantity of the animal bone discarded at Buang Merabak. It is described from Units 2 and 1.

2.2 Resource use in Unit 2

The results in tables 18 and 19 list the taxa present in Unit 2. *P. orientalis* is 82% of NISP and 93% by weight of post-cranial elements. The next largest contributor to the assemblage was the

Megapteroptera that was 17% of NISP and 6% by weight and reflecting a large drop in its contribution compared to Unit 3. The *T. browni* appears in the assemblage for the first time and contributes less than 1% of both NISP and weight. What follows is an investigation into the possible impact of the *T. browni* on human consumption patterns beginning with a discussion about its human translocation into New Ireland. This is followed by a discussion about the nature of *P. orientalis* resource use and hunting and how it reflects land use and mobility.

2.2.2 Human Translocation - Thylogale browni

Prior to this analysis the *T. browni* first appeared in the New Ireland diet at 8000 bp (Allen et al. 1989). The results in table 25 indicate that one specimen appears in Unit 3 and 10 appear in Unit 2. The former is interpreted as intrusive into Unit 3 and therefore the introduction of the *T. browni* into the New Ireland diet was interpreted as occurring in Unit 2. *T. browni* is potentially very important because in specific cases small Macropods play an important role in the human diet as exemplified by the hunting of *Macropus rufogriseus* in Pleistocene Tasmania (Cosgrove 1990), *Dorcopsis muelleri* in the Bird's Head of New Guinea (Pasveer 2003) and to a lesser extent *T. browni* at Balof 1 and 2 in northern New Ireland (Downie and White 1978:773; White et al. 1991). While it is represented by a low NISP at Buang Merabak it was compared with the other taxa in terms of consumption intensity for reasons outlined below.

2.2.3 Consumption Intensity

The introduction of the *T. browni* into New Ireland had the potential to have a significant impact on the human diet. With an average weight of several (5-7) kilograms it was three to four times larger than the next largest prey taxa, namely *P. orientalis,* and represented a larger meat package and therefore a larger protein source. Theoretically, if it can be hunted or captured, ignoring cultural idiosyncrasies, with the same or a lower expenditure of energy than the pre-existing New Ireland terrestrial prey taxa, namely *P. orientalis*, then on purely economic grounds it would have become the preferred prey taxa.

A number of datasets were investigated in order to evaluate the impact of *T. browni's* introduction on the human consumption. The *P. orientalis* is compared before and after the introduction of *T. browni* to determine whether the introduction of the latter had any impact on the former. The data in table 25 indicate the NISP of *T. browni* was never high (n=20 for TP1B) and the MNI was never greater than one in either of the units in which it was present. The low quantity of *T. browni* suggests a minimal impact on human behaviour and therefore a negligible impact on the nature of the predation and consumption of the *P. orientalis*. The NISP of the *P. orientalis* post-cranial specimens actually increases in the same unit that represents the introduction of *T. browni* (see table 25).

P. orientalis consumption intensity, as expressed through a comparison of green fractures between units, increases in relation to *T. browni*. The results in table 25 indicate that Unit 3 *P. orientalis* accounts for 20% of total green fractures and increases in Unit 2 to 24.64%. This suggests that the introduction of the *T. browni* had very little impact on the nature of consumption of *P. orientalis* at Buang Merabak.

2.2.4 Generalist or Specialist Hunting?

Unit 2 was remarkably different in composition to Unit 3. The overall taxa variety increased to include the *T. browni* and a new *Rattus praetor* (see Appendix 9). The results in tables 18 and 21 exhibit a large reduction in the quantity of the *Dobsonia* sp. taxa. Compared to the *P. orientalis* the percentage of *Dobsonia* sp. drops substantially and the *P. orientalis* becomes the dominant prey taxon. The numerical dominance of *P. orientalis* in the assemblage is far greater than was the dominance of the *Dobsonia* sp. in Unit 4, suggesting a change from specialist *Dobsonia* sp. hunting to specialist *P. orientalis* hunting.

Curiously, the inclusion of the *T. browni* had very little impact on the Buang Merabak diet. The nature and dominance of the *P. orientalis* allow for the investigation into specialisation to be undertaken at the intra-taxa level that is not possible with the Megapteroptera.

2.2.5 Intra-Taxa Analysis

Certain categories within a population may be more desirable to the hunter. For example, historically the seal fur trade was dominated by juvenile seals and in a contemporary context a higher social and economic value today is placed on lamb over mutton. The data presented in Chapter 4 indicate that two taxa, the *D. anderseni* and *P. orientalis*, were at separate times, the focus of hunting in the vicinity of Buang Merabak. Of these two the *P. orientalis* provides the best opportunity to investigate the nature of intra-taxa selectivity by utilising mortality profile data because its diagnostic characteristics allow for a higher degree of confidence in the results. A mortality profile represents age at death and produces results reflecting whether a specific age-group, within the taxa, had a tendency to be captured at a greater rate than any other.

2.2.6 Mortality Profile Models

Different age groups inform notions of predator behaviour and possibly selectivity as a reflection of specialisation. For example, demographic modeling indicates that a catch dominated by juvenile animals suggests a 'chase' capture strategy and alternatively if it is dominated by adults suggests an 'ambush' strategy. This is based on the assumption that adult animals will lead the escape, leaving younger slower animals to be captured. An ambush strategy will result in a greater proportion of adults because it targets individuals randomly and a natural population statistically contains more adults (Bulmer 1968; Stiner 1991). The interpretation of mortality profile data requires an appreciation of natural population dynamics in order to conceptualize notions of generalist/specialist hunting. What follows is a definition of generalist/specialist hunting in the context of a mortality profile followed by a theoretically modeled natural population and discussion on the subject of its applicability.

In the intra-taxa context selective hunting reflects predator preference for a particular age class within a population. A generalist hunting strategy manifests itself in a mortality profile with a distribution that reflects a natural population because statistically every age group has an equal chance of capture. A natural population theoretically is a pyramidal or stair case shape containing a large number of the youngest animals followed by a successively reducing number of older animals represented in table 66 (Stiner 1991:6-7).

A mass kill site (for description see Lyman 1997:169) will contain a large number of individuals of all ages and the mortality profile will be L-shaped (Lyman 1997:128; Stiner 1990, 1991). However, this sort of analogue is not directly applicable to the *P. orientalis* because they are not herding animals.

Fortuitous hunting also reflects a mortality profile of a natural population. It is a strategy that involves the pursuit of any animal that crosses the path of the hunter. The hunter tends to catch the animals whose behaviour commonly spatially overlaps with the hunter's territory. Spatial overlap refers to the amount of mutual or common territory utilised by both the hunter and the prey. The nature of the catch will be the result of a combination of highly dependent contingencies reflecting the behaviour of both the hunter and the prey. If both hunter and prey predominantly spend a relatively large percentage of their time within the mutually common territory the catch will reflect a wide range of animal taxon, ages and sizes and therefore might be characterised as a generalist strategy. However, this might be complicated in specific circumstances such as if the prey only visit the territory of the hunter for specific purposes such as breeding or seasonal feeding. For instance, if a hunter fortuitously and irregularly visited a beach and the visit coincided with a breeding population that only visits the beach very rarely (e.g. the Green turtle of Sarawak), and then the fortuitous predator can only select prey from a predetermined cross-section of the prey population. The catch will necessarily be skewed towards a section of the population simply because only that section is available. This scenario is assessed by an informed understanding of the behaviour of both the hunter and prey. Fortuitous or generalist hunting is highly likely to produce a mortality profile reflecting a random profile of the population.

A specialist hunting strategy is reflected by a disproportionate presence of one or a number of discrete age groups within the mortality profile. Commonly younger and older individuals are over-abundant producing a 'U-shape' mortality profile (Stiner 1991:7-8). A U-shape profile illustrates emphasis on the younger and older animals at the expense of the mid-range animals. Once again this is common to predation on herding animals and therefore only a guide in the interpretation of the *P. orientalis* data.

2.2.7 Mortality Profile Method

A mortality profile was constructed by utilising a number of different data sets. Age at death was determined by recording whether epiphyses are fused, by measuring the length of the tooth row (see White et al. 1991), tooth eruption (Pasveer 2003:236-270) or by the rate of tooth-wear (Winter 1980). If the data were skewed towards a particular age group they might be interpreted as suggesting that the age-group reflects something about the predator/prey relation assuming that a more parsimonious explanation cannot be brought to bear. The data collection methodology was described in Chapter 4. The data presented in table 58 and figure 15 reflects the nature of molar tooth wear on the Buang Merabak TP1B *P. orientalis* assemblage.

The data in table 58 indicate that younger animals were more common than older animals. This may reflect one of two things: first, the structure of the prey taxa population in the past (Pasveer 2003:268); and secondly, notions of predator/prey interaction. To distinguish between the possibilities requires a description and discussion of the concept of a theoretical 'natural' population.

2.2.8 Natural Population

Notions of a 'natural' population are difficult to conceptualize because the impact potentially of environmental conditions (long term such as vegetation alteration brought on by glacial cycles and short term such as catastrophic events like volcanic activity), disease and predation by any non-human predators has the potential to keep the natural population level in a constant state of flux. In this context, all factors that put pressure on a population, including the human predator, are in fact natural. However, for the purposes of this discussion, 'natural' reflects non-humans factors.

Table 66: Hypothetical population structures of a natural population. 'Age' represents the cohort from '1' equaling youngest to '5' = oldest. Values represent the percentage of the population in each age cohort (Pasveer 2003:268).

Age	Expanding	Equilibrium	Reducing
1	40	40	1
2	38	30	7
3	14	20	14
4	7	8	38
5	1	2	40

A natural population will differ from the theoretical population depending upon whether it is expanding, in equilibrium or contracting (Pasveer 2003:268). An expanding population is dominated by younger individuals (see table 66 and figure 20). A population in equilibrium with the environment reflects a 'normal' population curve (Stiner 1991) or a standard pyramid profile. And a contracting population has fewer younger individuals than older individuals. Any comparison with a theoretical natural population profile requires that the archaeological data reflect a random harvest of the available resources (Pasveer 2003:268).

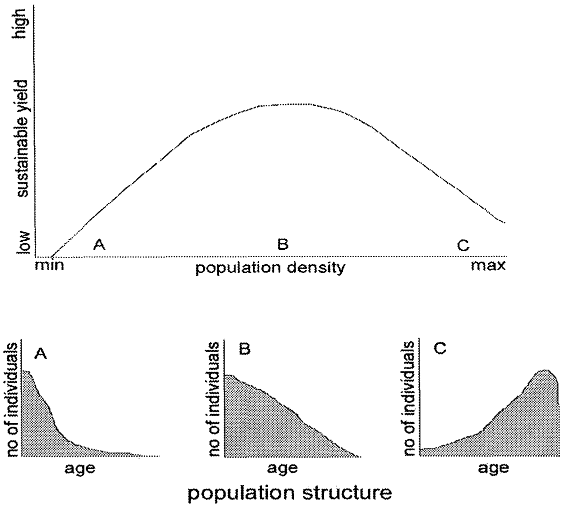

Figure 20: Pasveer's natural population model (from Pasveer 2003:268)

In order to utilize the archaeological material as an environmental indicator reflecting the natural population in the past, three criteria must first be addressed. First, it must be demonstrated that the archaeological assemblage reflects a cross-section of the natural population. The ethnographic evidence indicates that hunters go hunting with a particular prey in mind and are not generally 'random cullers' of available prey (Bulmer 1976). For example, Bergman (1961:116) describes a particular outing with the purpose of specifically collecting flying fox from a known location during which only flying fox were captured. Bjerre (1957:92) describes the hunting of possums and birds for the occasion of the birth of a child. Goodale (1966) indicates that arboreal fauna are hunted using bamboo blowpipes. Powdermaker (1971[1933]:188-189) describes the different requirements for hunting pigs as opposed to cuscus. Clay (1974:17) indicates "elaborate techniques were once used in shark catching expeditions". Bulmer (1968) and others (Anell 1960; Dwyer 1982; Dwyer and Minnegal 1991) describe a range of hunting techniques developed to capture specific prey taxa. The examples, from different contexts, reflect either prerequisite knowledge or technology that indicates planning for the capture of specific prey during hunting trips. This is not to say that alternative prey will not be captured serendipitously but that the 'prey of choice' is likely to be statistically the most prevalent in the catch of the hunter and this is likely to be reflected in the archaeological record.

Secondly, accepting that hunters were effectively random cullers of the environment they would not capture a random sample of the prey population because of the idiosyncratic behavior of both predator and prey. For example, the placement of a trap on a tree branch is more likely to capture arboreal taxa than ground dwelling taxa simply because of the vagaries of animal behaviour. In this context, apparently random predator and/or prey behavior does have an influence on hunting outcomes and will be discussed further below.

Thirdly, the Buang Merabak data derived from units covering between 2000 and 5000 years respectively. Assuming a relatively stable environment (Hope pers. comm.) and dynamic *P. orientalis* population levels, the Units extend over broad enough periods of time to even out short to medium term changes in population.

The Buang Merabak evidence does not easily fit any of the criteria for its interpretation as a reflection of the natural population and therefore this line of analysis will not be pursued further. The second and more likely possibility is that the data reflect notions of predator/prey interaction. It is proposed that the predominance of individuals in the younger age cohort was a product of two complimentary processes of human strategy and the behavioural ecology of the prey taxa.

First, as described in Chapter 2, juvenile Phalangerids have a tendency to disperse in search of territory within 12 months of birth and dispersal can extend over relatively great distances. Coupled with inherent juvenile naivety, dispersal behavior has the potential to put the animal at relatively greater risk to accident or predation than other age groups within the population. Older individuals have an established territory and were likely to be more familiar with the potential dangers and therefore more cautious of them. The youngest dependent animals might also be in less danger through their reliance on the life experience of their mothers on which they were dependant. The ecological requirement of the young cohort of the population, to establish their own territory, potentially puts them at relatively greater risk to predation than other sub-groups of the population.

Secondly, the predominance of *P. orientalis* in the assemblage, particularly in Unit 2, reflected a human preference for the taxon over other prey. It suggests that hunters generally went looking for *P. orientalis* and engaged in techniques that increased the chances of hunting success. The

Buang Merabak data might therefore be interpreted as a reflection of human targeting of the taxa and the capture of the most naïve individuals within the *P. orientalis* population.

This interpretation suggests that intra-taxa selection did not explicitly occur. Rather a combination of targeting at the taxa level coupled with prey naivety is the most parsimonious explanation for why those in the young animal cohort are the most prevalent within the assemblage.

In a broader spatial context, the Balof 2 assemblage contains a large quantity of *P. orientalis* specimens reflecting a MNI of 299. Measurements were taken on 168 mandibles or maxillae tooth rows (P^3 to M^5) in order to assess the possibility of change in size over time. The results indicate that size did not vary over time (White et al. 1991:53). The Buang Merabak data tends toward a change over time to an emphasis on younger individuals. These apparently contradictory data can be interpreted in three different ways.

First, they may reflect different hunting behaviour between central New Ireland (represented by Buang Merabak) and northern New Ireland (represented by Balof). A tenuous indication of this might be the greater quantity of *T. browni* in the Balof assemblage (White et al. 1991) than at Buang Merabak and the significantly different nature of the Panakiwuk faunal assemblage (Marshall and Allen 1991).

Secondly, the apparently different results may have be a function of the different methods utilised in each study. White et al. (1991) measured the length of the tooth row as a proxy for size while Leavesley (in prep.) utilised tooth wear and eruption analysis. Therefore, it might be possible that both datasets, although apparently different, are representing the same trend in different ways. Thirdly, assuming all things between the two sites are equal, the data might be interpreted as indicating that the *P. orientalis* grows to its maximum size relatively young in life. While the Buang Merabak assemblage reflects a relatively young population, the individual animals need not have been much smaller than a mature adult. It also suggests that there may have been little advantage for the hunter in selecting for size. This may explain why even when the *P. orientalis* were at the peak of their importance to the human diet (in Unit 2), the age profile of the catch did not alter significantly.

2.2.9 Mortality Profile - Summary

The mortality profile data indicate an over-abundance of animals in the young cohort. This indicates that human predators were either selectively capturing young animals or found them easier to catch without the prey being necessarily any smaller in size.

The expectations of the optimal foraging model indicate that the human hunter will catch the highest value (in terms of overall energy revenue versus expenditure) prey. The overall assemblage contains a variety of taxa that in this context might be interpreted as inefficient (or non-optimal) prey selection such as Reptilia, Rodentia and Aves. However, the dominance of the *Dobsonia* sp. taxa in Units 3 and 4 and then the *P. orientalis* might be interpreted as an indication of reasonably efficient prey selection. With reference to the *P. orientalis* mortality profile, the capture of younger individual prey animal may reflect the optimal selection given a number of assumptions that were difficult to test. The data were interpreted as suggesting that the *P. orientalis* attain nearly the size of mature adults at a relatively young age and that they were much easier to catch than the mature adults. Therefore their capture as human prey reflects optimal hunting behaviour within the New Ireland context.

2.3 Resource use in Unit 1

The results in tables 16 and 17 list the taxa present in Unit 1. The *P. orientalis* was 67% of the NISP and 82% of unit weight of post-cranial elements. The next largest contributor to the assemblage was Megapteroptera contributing 29% of the NISP and 13% of unit weight. Evidence of *S. scrofa* appeared in the site for the first time and was represented by one tooth fragment.

2.3.2 Human Translocation

Unit 1 contains evidence of three new introductions to New Ireland. They were *R. exulans, R. praetor* and *S. scrofa*. Rodentia were present throughout all the units in low quantities. Although good ethnographic evidence exists for the consumption of Rodentia by humans (Hide et al. 1984:291-380), the relatively small size of Rodentia bones made it difficult to definitively determine the extent to which it was present in the Buang Merabak assemblage. *Rattus praetor* was also thought to be a human commensal although the timing of its introduction into New

Ireland is as yet unclear (White et al. 2000). Although no specimens of *R. praetor* have been definitively identified in the Buang Merabak assemblage (Appendix 9), the introduction of *R. praetor* in the Early-Holocene, as evident at Panakiwuk, had little impact on the overall human diet. *R. exulans* was introduced as part of a new population and subsistence regime associated with the Lapita Cultural Complex (Spriggs 1997). While Lapita appears to have had a huge impact on New Ireland through the introduction of agriculture, the introduction of *R. exulans* had little direct impact on the diet as represented at Buang Merabak.

S. scrofa first appeared in the Buang Merabak assemblage in spit 11 and equates with the period 12,000 bp to 7000 bp (Unit 2). The single *S. scrofa* specimen was the cusp of a canine weighing 0.06 gms. Given the low number (n=1), the small size of the specimen and its stratigraphic proximity to the interface of Units 1 and 2 (being between spits 8 and 9), it was interpreted as the result of downward vertical re-distribution from Unit 1 in line with Leavesley and Allen (1998).

S. scrofa, Gallus gallus and *Canis familiaris* (the latter two were not present in the Buang Merabak assemblage) were Austronesian introductions (Bellwood 1978) and therefore their presence in the assemblage suggests a degree of impact on the pre-existing populations. However, as *S. scrofa*'s contribution was minor, its impact on consumption at Buang Merabak might be described as low. However, the indirect impact of *S. scrofa*, at Buang Merabak was to indicate the indirect meeting of two economic systems, the hunter/gatherers represented by the Buang Merabak assemblage and the agriculturalists who introduced the pig into the New Ireland biota.

2.3.3 Generalist/specialist hunting

The relative quantities per taxon in Unit 1 are similar to Unit 2 (above). *P. orientalis* was more than 60% of the assemblage by both NISP and weight and the *Dobsonia* sp. were the majority of the remainder. The results follow the pattern described for Unit 2 in that the *P. orientalis* was the dominant prey taxon in the assemblage. It also suggests that little changed in prey selection since Unit 2.

3. HUNTING STRATEGIES

3.2 Hunting Strategies in Unit 2

The hunting strategies associated with the predation of *Dobsonia* sp. were described in Chapter 5. The *P. orientalis* mortality profile indicates a degree of emphasis on the capture of younger animals suggesting some strategies are more likely than others. The inclusion of the *T. browni* was an additional forest-dwelling animal in the diet. Its ecological and behavioural characteristics suggest a number of hunting strategies associated with its predation that were different to both the *Dobsonia* sp. and *P. orientalis*.

3.2.2 Phalanger orientalis Hunting

Based on the ethnographies described in Chapter 2, *P. orientalis* were captured by a variety of methods all of which include a working knowledge of the ecology and behaviour of the taxon. *P. orientalis* hunting occurred in the rainforest as opposed to the cave (see *Dobsonia* sp.). The most common methods include combinations of preliminary investigation, stalking, ambush and the use of projectiles. A preliminary investigation might be part of the strategy in order to identify nesting sites and pathways that were recently and commonly used by the prey. Once a location had been identified a trap or ambush could be set up to capture the prey when it became active at dusk.

The *P. orientalis* mortality profile (see table 58) suggests an emphasis towards hunting strategies that target nests. Hunting techniques such as the 'besetting' method was a common method of obtaining arboreal mammals (Bulmer 1968:310) which have their lairs in tree hollows and were in some cases difficult to extract and capable of injuring the hunter if tackled by hand. Smoke may be used to force them out (also described for Australia by Anell 1960: Plate II) or hooks or pointed sticks to extract them (Bulmer 1968:311). The advantage of these methods is that they do not require a high level of technology and are therefore based on knowledge that might reasonably be acquired through observation.

3.2.3 Thylogale browni Hunting

The ethnography indicates two aspects of *T. browni* hunting. The agility of the *T. browni* necessitates a hunting strategy that enables the hunter to get close to the prey in order to strike. The importance of the stalking approach has an inverse relationship to the power and accuracy of the hunter's weapon. *T. browni* have been recorded up to 3 to 4 times the size of *P. orientalis* and therefore its capture requires a weapon of some description, probably a projectile or club. New Ireland ethnography includes spears (Clay 1974:17), clubs (Parkinson 1999[1907]:129), slings and blow pipes (Bulmer 1968:307), although it is not clear how far this information can be extrapolated into the past. Assuming a relatively low level of technology stalking is a fundamental part of the hunting process; an alternative to stalking may be an ambush or trapping. The second aspect of *T. browni* hunting is the chase. This is almost inevitable because *T. browni* is both easily startled and agile. The extent of the chase directly reflects the quality of the stalking and the nature of the weapon. If the stalking is effective, and the prey remains unaware of the predator until the last moment, then the chase will be minimal and vice versa.

The topography influences the predation of the *T. browni* and *P. orientalis* in different ways. As described above (see Chapter 6), the primary means of escape for the *P. orientalis* is to retreat to the forest canopy. Therefore the nature of the terrain has very little impact on its ability to avoid capture and the hunting technique described above might reasonably be implemented throughout New Ireland. The primary means of escape for *T. browni* is its speed across the ground. The human predator is less adept at moving across the rugged terrain and therefore, there is a direct relationship between *T. browni's* ease of escape and the ruggedness of the terrain. In the Buang Merabak hinterland and indeed most of central and southern New Ireland the limestone karst geology and the steep and mountainous topography make for extremely rugged terrain, the worst of which exists on all but the northeast coastal plains. Therefore, the stalking strategy has the same probability of success in any terrain because it is not a terrain-specific strategy. However, if a chase strategy is implemented the *T. browni* has a greater chance of escape in the rugged central and southern New Ireland than the relatively less rugged north eastern area. This is because, while the terrain inhibits both predator and prey, the *T. browni* has a greater capacity to move across rugged terrain than the predator, providing it with a crucial edge.

Assuming minimal weapons technology, the ecological and behavioural characteristics of *T. browni* suggest that stalking and chasing were the primary capture strategies employed by hunters. In New Ireland it was relatively difficult to chase prey across the rugged parts of the central and southern mountains and relatively easier in the comparatively flat north east.

3.2.4 Unit 2 Hunting - Summary

The primary terrestrial based prey taxon was *P. orientalis*. It can be captured in the rainforest that constitutes the hinterland of Buang Merabak. There was less evidence of *Dobsonia* sp. hunting in the cave and even less evidence of *T. browni* hunting.

3.3 Hunting Strategies in Unit 1

The Unit 1 assemblage was relatively similar to Unit 2, with *P. orientalis* the dominant prey taxa followed by *Dobsonia* species. The hunting strategies were similar to those described for Unit 2. Those associated with the predation of *Dobsonia* sp. remain the same as described in Chapter 6. The *P. orientalis* mortality profile indicates a degree of emphasis on the capture of younger animals suggesting some strategies are more likely than others. The chase strategies tend to favour the capture of younger animals and this might explain their slight increase in the assemblage. *T. browni* was also present in Unit 1. Its ecological and behavioural characteristics suggest a number of hunting strategies associated with its predation that were different to both the *Dobsonia* sp. and *P. orientalis* as described for Unit 2.

4. LAND USE

4.2 Land use in Unit 2

Land use in Unit 2 changes number in line with resource use and hunting strategies. There is a break from Unit 3 that primarily indicated consumption of prey collected at the site to consumption of prey collected away from the site.

4.2.2 Site Use (On Site)

The Unit 2 assemblage was dominated by *P. orientalis* and complimented by a much smaller amount of *Dobsonia* sp. than in previous units (tables 18 and 19). As described above, the *Dobsonia* sp. reflects the continuation of hunting activities in the cave. *P. orientalis* was brought to the site from the rainforest hinterland and reflected the use of the site for the specific purpose of *P. orientalis* consumption.

The high quantity of *P. orientalis* and the relatively low quantity of *Dobsonia* sp. suggest a break from Unit 3 in that the primary use of the cave changed to the consumption of the former and to a lesser extent the predation and consumption of the latter.

4.2.3 Land Use (Off Site)

Unit 2 contains a high percentage of *P. orientalis* complimented by lower numbers of other taxa (families: Scinidae, Varanidae and Muridae). It reflects the extensive use of the rainforest in the hinterland of the site for hunting. Although predation of *Dobsonia* sp. continues, the much larger quantity of forest dwelling taxa (mainly the *P. orientalis*) suggest a much greater emphasis on the forests for the acquisition of terrestrial prey resources. Overall there is more evidence for the use of the forests than the cave for hunting.

Table 67: Percentage of all taxa in Unit 3 by habitat and body part from tables 20 and 21. Weight =grams.

	Bush		**Cave**		**Bush/cave**	
Taxa	**NISP**	**Wt.**	**NISP**	**Wt.**	**NISP**	**Wt.**
Cranial	86.83	95.3	11.92	4.18	1.25	0.25
Post-cranial	83.26	93.47	0.09	0.14	16.63	6.38

The results shown in table 67 were very different to those described for Units 4 and 3. The technicalities involved with interpreting there data were similar to those described for table 61. The results indicate a greater emphasis on taxa that represent the use of the forests as a hunting locale rather than the bush. The results in table 65 provide a different view on the same dataset by presenting the MNI per taxon per unit. *P. orientalis* was represented by a relatively high MNI, NISP and weight data in table 65. The *P. orientalis* MNI has a ratio of 6:1 *D. anderseni* in Unit 2. The dominance of *P. orientalis* in the human diet in Unit 2 marks a change in land use in relation to consumption behaviour at Buang Merabak. It indicates that while resources were still being acquired at the site itself they were supplemented to a large extent by resources obtained in the rainforest as well. It also has implications for hunter/gatherer concepts of space. While the division occurs to a small degree in Units 3 and 4, Unit 2 reflects a change in the overall kind of behaviour. A majority of hunting behaviour occurred in the rainforest hinterland before the catch was brought to the site for consumption.

4.3 Land use in Unit 1

Unit 1 primarily contains evidence of *P. orientalis* as the dominant prey taxa distantly followed by *Dobsonia* species. Both on site and off site land use remains similar to that described for Unit 2.

4.3.2 Site Use (On Site)

As described in Chapters 5, the *Dobsonia* sp. reflects hunting activities in the cave but at a reduced rate. The high quantity of *P. orientalis* and the relatively low quantity of *Dobsonia* sp. suggest that the primary use of the cave was the consumption of the former and to a much lesser extant the predation and consumption of the latter.

4.3.4 Land Use (Off Site)

Unit 1 contained a high percentage of *P. orientalis* complimented by a lower NISP of other taxa (families: Scinidae, Varanidae and Muridae). As described for Unit 2 *P. orientalis* reflects the extensive use of the rainforest in the hinterland of the site for hunting. The *P. orientalis* MNI has a ratio of 6:1 *D. anderseni* in Unit 2. The dominance of *P. orientalis* in the human diet in Unit 1 marks a continuation from Unit 2 in the land use in relation to consumption behaviour at Buang Merabak. It indicates that while resources are still being acquired at the site itself they are supplemented to a limited extent by resources obtained in the rainforest as well.

The prevalence of *P. orientalis* in the site indicates three things. First, they were the primary terrestrial protein resource at the site. Secondly, hunters spent a large proportion of terrestrial protein acquisition time in the rainforests in the hinterland of the site. And thirdly, the site is used primarily for their consumption.

5. MOBILITY

5.2 Mobility in Unit 2

Unit 2 contains a high proportion of *P. orientalis* with some interesting implications for mobility in the hinterland of Buang Merabak. First, it reflects an increase in the amount of time and resources spent in the forest as opposed to the cave. All the activities associated with *P. orientalis* hunting occurred within the forest and therefore mobility through the forest is relative slower because it now includes an increased emphasis on hunting compared to that described for Unit 3 and especially Unit 4 (see Chapter 6).

The presence of *P. orientalis* represented a dispersed resource that reduces the intensity of mobility between base camps in two ways. First, the ubiquitous distribution of the resource means that movement through the rainforest to the next camp site may also include hunting activities in pursuit of prey, therefore reducing the rate of movement between base camps. Secondly, as described above, the focus of behaviour at the site was towards consumption behaviour. The primary focus of hunting was in the forest hinterland of the site. The exploitation of the forest resources requires a higher rate of hunting mobility which in itself equates with either increased overall mobility or longer stays at consumption sites such as caves (Binford's 1980 base camp) allied with increased hunting mobility.

The high rate of *P. orientalis* consumption also serves to reduce the hunter's dependence upon the high density resource patches, reducing the tethering effect with the result of increasing the flexibility of land use. *P. orientalis* inhabits all rainforest environments in New Ireland and therefore imposed few restrictions on the human mobility other than the necessity to move on when an area has been hunted out. Additionally, the *P. orientalis* reflects behaviour beyond the scope of Binford's (1980) foragers and incorporates crucial aspects of collectors through the spatial division of activities.

5.2.2 Unit 2 Mobility - Summary

The data suggest a relatively low base camp mobility strategy in conjunction with a relatively high hunting mobility strategy in which the prey, at least in part, were brought back to the camp site for consumption.

5.3 Mobility in Unit 1

Unit 1 remains relatively similar to Unit 2 with *P. orientalis* the dominant prey taxa followed by *Dobsonia* species. They reflect land use similar to that described for unit 2.

5.3.2 Mobility - Summary

The data suggest a relatively low base camp site mobility strategy in conjunction with a relatively high hunting mobility strategy in which the prey were brought back to the camp site for consumption. The results indicate high hunting mobility and low base camp mobility. The ubiquitous nature of *P. orientalis* distribution suggests that the hunters were not tethered to any particular location within the rainforest.

5.4 Unit 1 Discussion

As described in the introduction to this Chapter, Unit 1 coincides with Late-Lapita in New Ireland which therefore warrants particular consideration. The pre-Lapita population in New Ireland is associated with Non-Austronesian languages and the Lapita populations with Austronesian languages (Specht in press). The results described above indicate that Non-Austronesian hunter/gatherers occupied Buang Merabak prior to the appearance of the Late-Lapita agriculturalists in New Ireland. The evidence from Lasigi indicates the presence of a Late-Lapita village nearby (3 km) to Buang Merabak. Lapita represents an incursion of people into the Bismarck Archipelago. The earliest Lapita sites occur on the off shore islands such as those in the Kandrian, Mussau, the Duke of Yorks and Anir at 3200 bp. Late-Lapita sites appear on New Ireland at Pinikindu, Lesu, Lamau, Bagial and Lasigi (Kirch 1997; Spriggs 1997). In the context of Lasigi and Buang Merabak it is unclear to what extent they reflect behaviour by different populations. Green describes Lapita colonization as a combination of cultural intrusion, integration and innovation (Green 1991, 2000). Green argued that some cultural baggage was brought by the Austronesians, some was integrated from pre-existing cultures indigenous to specific regions and some were innovations. In this sense to what extent was Unit 1 the result of the fusion of Austronesian and Non-Austronesian cultures? On the one hand, do the two sites reflect different behaviour derived from distinct linguistic origins with equally distinct subsistence strategies, or is Unit 1 the product of an interaction between the two sets of people? One way to begin to investigate this issue might be to investigate whether the behaviour of the pre-existing population changed after the appearance of the new village at Lasigi. The results presented above suggest a number of changes did occur in the assemblage. Overall, Unit 1 represents an increased deposition rate (table 14) suggesting an increase in the use of the site. Unit 1 contained fewer *P. orientalis* mandibles (table 57) and the specimens were on average smaller (see table 25), suggesting a higher rate of fragmentation.

One way to investigate the question of the impact of agriculture on New Ireland is to look at the intensity of consumption on *P. orientalis* compared the previous Unit that does not represent agriculture. If the impact of agriculture is high then consumption intensity on *P. orientalis* is likely to decrease and vice versa. In order to investigate this proposition the following analysis assumes that the absence of sub-elements reflects human consumption of that aspect of the element. Secondly, proximal femora and humeri diaphyses and epyphyses contain a larger amount of meat and therefore protein than the distal diaphyses and epiphyses. If more distal epiphyses are present than proximal epiphyses this might be interpreted as an increased intensity of consumption of meat and vice versa.

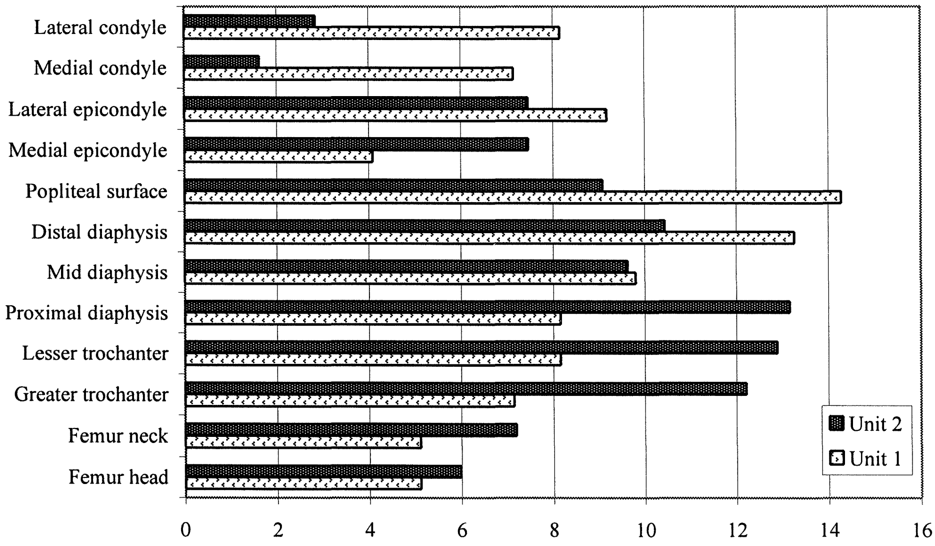

Figure 21: *Phalanger orientalis* TP1B percentages of femur sub-elements per unit.

Figure 21 illustrates the distribution of femur sub-elements for both Unit 2 representing the Pleistocene/Holocene transition and Unit 1 representing the period contemporaneous with Late-Lapita. The femur head represents the proximal epiphysis of the element and the lateral and medial condyles represent the distal epiphysis. Figure 21 indicates that Unit 2 contains a higher percentage of proximal femur sub-elements in comparison with Unit 1 which contains a greater proportion of distal sub-elements.

Figure 22 illustrates the sub-element results for *P. orientalis* humeri from Units 2 and 1. The Humerus head represents the proximal epiphysis of the element and the foramen represents the distal epiphysial end. It also indicates that Unit 2 has a greater proportion of proximal sub-elements in comparison with Unit 1 and has a greater proportion of distal sub-elements.

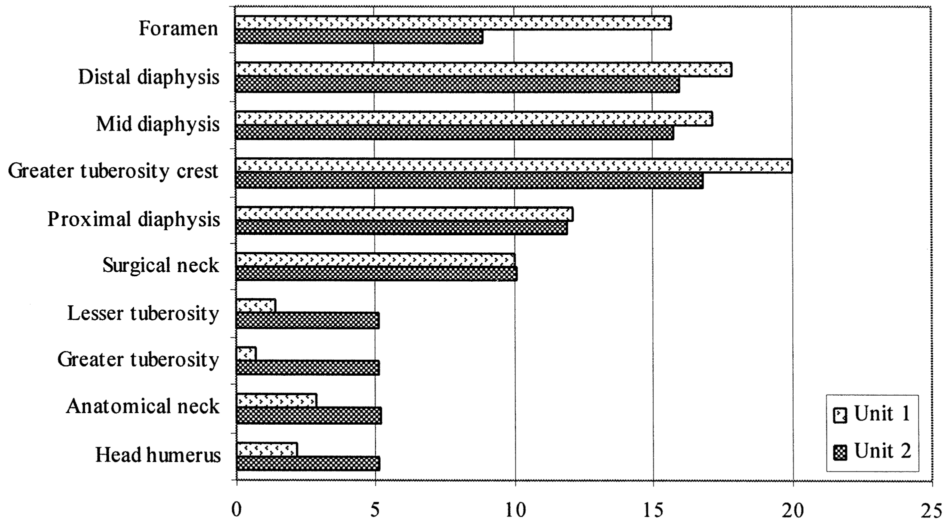

Figure 22: *Phalanger orientalis* TP1B percentages of humeri sub-elements per unit.

The results in figures 21 and 22 indicate an increase in the absence of proximal sub-elements in Unit 1 compared to Unit 2. This suggests an increase in the intensity of consumption of the proximal aspects of the respective element that contain a higher quantity of meat than the distal elements. Therefore, results suggest that the impact of agriculture at Lasigi had little impact on the nature of *P. orientalis* at Buang Merabak.

6. CONCLUSION

Units 2 and 1 saw the introduction of a range of taxa into the diet. Unit 2 exhibited the earliest evidence of the *T. browni* and Unit 1 contained the *S. scrofa* and *R. exulans*. All three taxa occurred in small quantities and did not play a major role in behaviour in relation to the site.

Both Units 2 and 1 were dominated by *P. orientalis* suggestive of hunting strategies that specifically targeted the taxa. The mortality profile of *P. orientalis* reflected the presence of a higher percentage of younger animals reflecting hunting strategies that are consistent with their capture. The site use primarily reflected *P. orientalis* consumption activities. The domination of the terrestrial-based diet by the *P. orientalis* suggested that the forests were utilised extensively for prey collection. Base camp mobility was low while hunting mobility within the rainforest hinterland of the site was high.

The *P. orientalis* femora and humeri sub-element analysis indicated a higher proportion of the relatively higher meat-bearing proximal bone specimens in Unit 1 compared to Unit 2. The results indicate an increase in the intensity of the consumption of *P. orientalis* after the establishment of an agricultural village at Lasigi.

Chapter 8
Regional Overview and Future Directions

1. INTRODUCTION

This Chapter presents a discussion of the results and interpretations presented in Chapters 6 and 7 and combine them in the context of a regional overview. The overview is discussed in three spatial levels: the site, New Ireland and the Bismarck Archipelago and Solomon Islands region. The discussion describes the spatial and temporal boundaries implicit in the interpretations in order to illucidate the complexities of change over time in human behavior. The Chapter has three sections that reflect different interpretative scales. Evidence from other sites in the region is drawn into the discussion where appropriate in order to propose a regional model of behavior.

2. BUANG MERABAK

The previous Chapters describe interpretations for each Unit but do not explicitly describe change between the Units. Change over time occurs between all 4 Units in terms of resource use, land use and mobility.

2.2 Changes In Resource Use Over Time

The results described above were interpreted to suggest that change in resource use occurred with the shift from *Dobsonia* sp. to *P. orientalis*. The Unit 4 *Dobsonia* sp. skeletal material was heavily fractured (see Chapter 7) suggesting intensive processing as part of the process of consumption. The Unit 3 *Dobsonia* sp. skeletal material was less-heavily reduced than in Unit 4 suggesting less intensive processing prior to consumption and was interpreted as indicating a lower degree of dependence on *Dobsonia* sp. in the diet. Also the quantity (both weight, and NISP) of the family Reptilia dropped significantly in Unit 3.

P. orientalis was introduced into the diet in Unit 3 but was not dominant until Unit 2 and remained dominant in Unit 1 (Chapters 6 and 7). Unit 3 thus reflected the transition and Unit 2 the transference from a resource with an uneven but high density distribution to one with a relatively low density but even distribution across the landscape. In the context of optimal foraging theory the diet changed because the energy gained minus the energy expended in hunting *P. orientalis* was greater than for the *Dobsonia* species.

Also in Unit 2, *T. browni* was introduced and had very little impact on the diet. *P. orientalis* was the preferred prey and this has implications for hunting strategies and land use as described below.

The relative contribution to the site from the respective taxa in Unit 1 remained the same as Unit 2 although the consumption of the *P. orientalis* carcass became more intensive. The results in figures 21 and 22 indicate an increase in the absence of proximal sub-elements suggesting the increased consumption of the associated meat. However, other archaeological research in the circum New Ireland region indicates that the cultural landscape did change. Unit 1 reflects the period between 3500 bp to 1800 bp (3300 Cal. BP to 1300 Cal. BP) and coincides with the Post-Lapita period represented at the nearby Lasigi village Late-Lapita site (Golson 1991). Lasigi may represent the arrival of Austronesian agriculturalists in central New Ireland. The evidence presented in Chapters 6 and 7 suggests that irrespective of the Lasigi site resource use, hunting strategies, land use and mobility amongst central New Ireland's hunter/gatherers did not change markedly until after 1800 bp (1300 Cal. BP).

2.3 Changes In Hunting Strategies Over Time

The primary changes in hunting strategies were in line with the changes in resource use and occurred between Unit 2 and 3 and the change of the primary prey taxa from *Dobsonia* sp. to the *P. orientalis*. Optimal foraging theory and ethnographic analogy (see Chapter 2) suggest that cave roosting Chiroptera colonies were the most efficient means of obtaining high yields of protein in New Ireland. After Unit 3 the tables were turned and the *P. orientalis* became the most cost effective source of protein.

The two hunting strategies had a number of important differences. First, the focal point of *Dobsonia* sp. hunting was the caves while *P. orientalis* were in the rainforest. The former was designed to maximise the gains from a dispersed resource that occurred in high density patches. The caves that provide the habitat for *Dobsonia* sp. occupation reflect specific nodes on the landscape at which specific hunting activities occurred. The *P. orientalis* hunting strategy was designed to maximise the return from a low density and highly dispersed resource. Its distribution was equivalent to that of the rainforest and therefore downgraded the importance of the cave as a hunting site, while maintaining its role as a consumption site.

Secondly, the different hunting strategies were designed towards different quantitative objectives per activity. The product of *Dobsonia* sp. hunting was to capture multiple prey at each hunt while *P. orientalis* were captured primarily as individuals. This reflected the particular ecology of each of the prey taxa and was particularly constructive in considering the former and the family Pteroptera in general. The taxa can be captured as individuals but result in a lower return and require an increase in technology such as the bow and arrow (see Chapter 2). While the ethnographic record provides a variety of capture strategies, those described above reflect the optimal strategy in the face of the ecological parameters.

Thirdly, the methods reflect different rates of resource depletion. The *Dobsonia* sp. hunting strategy described in Chapter 6 was reminiscent of a mass kill site. The efficiency of the method dictates that those individuals that were not captured by the hunters might reasonably be expected not to return to the roost in the short term on account of having been traumatised by either the mass kill or the accompanying smoke. After the initial hunt any repeat effort will be rapidly subject to the law of diminishing returns that indicates that any repeat hunt will not produce yields as high as the first hunt. Chiroptera populations tend not to hurry back to their roosts after such an attack. The likelihood of a repeat hunt on the same colony yielding a greater overall return, including factoring in the energy cost of travelling to a new site, than the potential returns that might be gained if the hunters moved onto another pristine population, are relatively low. This has implications for mobility that will be discussed below. Alternatively, the low density homogenous distribution of the *P. orientalis* depletes at a much slower rate. This is because *P. orientalis* live at an approximate density of 5 individuals per km^2 and therefore their capture requires the investment of energy to move across the landscape in order to find to each individual animal prior to its capture and then the process needs to be repeated as necessary. Therefore, the depletion rate of each of the prey taxa occurred at different rates that had implications for their respective hunting strategies.

Lastly, the strategies reflect different planning requirements. *Dobsonia* sp. hunting may include prior knowledge of the location of the cave. Depending on the strategy, care might have been taken to collect vegetation for the construction of barriers prior to arriving at the cave to reduce time and noise. This strategy would reduce prey panic and keep the colony together while setting the ambush. There are three parts to cave bat hunting and they are barrier construction, the placement of the fire and ambushing of the fleeing prey. The two latter are concurrent requiring at least two people to maximise the yields.

P. orientalis hunting did not necessarily require pre-existing knowledge of nesting places in the same sense as the cave for *Dobsonia* sp. although does suggest pre-existing knowledge of its ecology and the rainforest environment. Its pursuit also requires stealth and agility and can be undertaken in hunting groups as small as one individual.

2.4 Changes In Land Use Over Time

2.4.2 Site Use (On Site)

The *Dobsonia* sp. in Units 4 and 3 reflect the use of the third chamber for hunting prior to the removal of the catch to the mouth of the first chamber for consumption. The *P. orientalis* in Units 2 and 1 reflect the off site capture of prey prior to consumption in the mouth of the first chamber. The primary use of the site changed in line with resource use and hunting strategies. In Units 3 and 4 the cave was used for predation and consumption. In Units 1 and 2 the amount of hunting undertaken at the cave was largely reduced and the site was used primarily for consumption.

2.4.3 Land Use (Off Site)

The predominance of *Dobsonia* sp. in Units 3 and 4 indicates a small amount of off site land use in relation to protein consumption at the site. Hunting in the rainforest for the family Reptilia supplemented by Rodentia, Muridae and Aves was indicated by small quantities of bone.

The *P. orientalis* was the dominant taxon in Units 1 and 2 and indicates that hunting occurred within the hinterland of the cave. This is contrary to Units 4 and 3 that indicate hunting within the cave itself. The hunting strategy described above requires extended hunting time spent in the rainforest in order to facilitate planning, tracking, stalking, ambushing, chasing and ultimately capturing the prey.

Collectively the results indicate a change in land use between Units 2 and 3. In Units 3 and 4 the cave is the focus of both hunting and consumption. In Units 1 and 2 hunting activities primarily occur in the rainforest and consumption continues to occur at the cave.

2.5 Changes In Mobility Over Time

Mobility changes between Units 2 and 3. In Units 4 and 3 *Dobsonia* sp. represented a high density resource patch in a depauperate environment. The exploitation of high density resources required a high mobility residential camp between nodes or locations on the landscape that represent high density resources and short stays at each of the nodes. The amount of time spent at each resource patch is relatively low because the resources were quickly exhausted. As described above, the *Dobsonia* sp. is easily frightened and therefore provides only one opportunity for predation per encounter. The combination of these three factors suggests that even a low degree of reliance on the taxa requires a high mobility strategy.

The *P. orientalis* represented a low density, relatively homogenous and dispersed resource. Its dispersed nature required a high mobility hunting strategy in order to catch more than one or two at a time. A greater amount of hunting time was spent in the rainforest prior to consumption at the cave site. It also suggests the possibility of a number of return hunting trips from the site cannot be precluded and in turn may reflect low residential camp mobility. *P. orientalis* hunting strategies suggest that residential mobility was reduced while hunting mobility increased and was consistent with previous analyzes (White et al. 1991:57).

Mobility changes between Units 3 and 2. In Units 4 and 3, residential mobility was high and hunting mobility low. In Units 2 and 1, residential mobility decreased and hunting mobility increased.

The primary change in the composition of the assemblage occurred between Unit 3 and 2. Units 4 and 3 contained high quantities of *Dobsonia* sp. and Units 2 and 1 contained high quantities of *P. orientalis* and had implications for hunting, land use and mobility. Hunting changed from a strategy of trapping large quantities of roosting *Dobsonia* sp. to tracking, stalking and chasing individual *P. orientalis.* Land use changed from a focus on caves as important nodes on the landscape for predation and consumption to the rainforest for predation while maintaining use of the caves for consumption. Mobility changed from high base camp and low hunting mobility to a low base camp and high hunting mobility strategy.

3.1 NEW IRELAND OVERVIEW

The results described in Chapter 3 suggest that the first humans to colonise New Ireland arrived at 39,590 bp and consisted of small groups of mobile hunter/gatherers (Allen 2000). After crossing the St Georges channel, a variety of resources was available including shellfish (Gosden and Robertson 1991), terrestrial fauna including *Dobsonia* sp., Reptilia, Rodentia and Aves (Leavesley and Allen 1998) and locally available stone from the creeks (Freslov 1989; Gosden and Robertson 1991; Leavesley and Allen 1998:69-74) and as described here in Appendix 10. The colonists had the advantage of being able to position themselves on the landscape as they liked, moving where necessary and staying put where possible. Low population densities may have given people room to move through the landscape in pursuit of its dispersed resources (Enright and Gosden 1992:173).

Allen and Gosden (1996; Gosden 1993:133) suggested that deliberate exploration as opposed to a more haphazard expansion might be reflected by a comparison of occupation dates from both sides of the Vitiaz Strait. Allen and O'Connell (2003) suggested the Huon Peninsula was occupied by 44,000 bp; in comparison, the Buang Merabak determinations from this research indicate occupation at 39,590 bp in New Ireland (Leavesley et al 2002). The determinations suggest that both sides of the Vitiaz Strait were occupied by around 40,000 bp and therefore the Buang Merabak results suggest the colonization of New Britain and New Ireland might be described as deliberate expansion.

Previous analyzes suggested the colonists were coastally oriented foragers. This was based on the quantities of midden shell, the location of the sites on the coastal margins and the relatively consistent distribution of marine resources across the region and beyond including the north coast of New Guinea and the Bismarck Archipelago (Allen 2000). Results presented in Chapter 6 suggest humans exploited forest-based resources from the beginning of colonization giving rise to two implicit implications. First, the colonists had the knowledge and ability to capture resources not only from the coastal fringe but also in the deep rainforest of New Ireland suggesting that they were not restricted or tethered (Binford 1980) to the coastal fringe. The case for the utilisation of the inland rainforests has been well made for New Britain (Pavlides 1999).

The New Ireland results are from coastal sites and therefore do not directly represent the rainforest zone but do indicate that there was no subsistence barrier to entering the rainforest. Secondly, in order to identify and utilise the rainforest-based resources such as the Chiroptera, Rodentia and Aves, the colonists must have been exploring the rainforest, to some degree suggesting a land-based colonization strategy. This may manifest itself as terrestrial exploration of the coastal fringe for terrestrial fauna and the littoral zone for mollusca rather than a watercraft based strategy.

The Buang Merabak Unit 4 faunal assemblage contains a vast proportion of *Dobsonia* sp. (see tables 40 to 44) suggesting that many of the terrestrial animals that were consumed at the site were captured at the cave rather than the littoral zone. *Dobsonia* sp. is relatively stationary while roosting making them an easier target compared to when they are in flight. They can be caught on the wing although it requires a higher degree of skill and the use of a projectile. Ethnographic evidence from other parts of New Guinea suggests the use of bows and arrows (Hide et al. 1984:351) and blow pipes (Goodale 1966) for limited areas of West Papua, New Britain and New Ireland (Bulmer 1968:307). The roosting *Dobsonia* sp. colony will inevitably fly away upon attack. When roosting in trees their prey has a relatively large area of open sky into which to escape from the predator. When roosting in caves the escape route is significantly limited. The behavior characteristics of cave roosting Chiroptera allied with the assumed low technological capabilities of the hunter suggest that the cave roosting taxa were the optimal prey. Once the bulk of the colony is either captured or escaped the cave was free of Megapteroptera until the colony re-established itself. This may or may not occur at the same location or in the short term and demonstrates the process of the rapid depletion of the cave as a resource patch. Subsequently, the hunter must decide on a strategy to supply the next meal of terrestrially-based protein and may select one of a number of ways. The hunter may opt for an alternative protein source from New Ireland's relatively depauperate fauna. This may include any of the animals with a small body size and low density distribution within the rainforest or the littoral shellfish resources that were brought to the site in small quantities from the coast. They have differing degrees of dispersal and are all relatively small protein packages and will therefore require a greater amount of energy expended for energy gained than a high density resource patch represented by another roosting *Dobsonia* sp. colony. In this instance, the spatial distribution of cave colony roosting habitats, that is caves, represents a series of high density resource patches across New Ireland that may or may not have been exploited systematically.

As described in Chapter 2 the New Ireland geography and topography were conducive to the presence of cave systems. The topography and geology indicate less limestone was exposed north of the Lelet Plateau than south of it. The quantity of limestone directly affects the number of caves. The distribution of limestone suggests that more caves are likely to exist in greater density in, and south of, the Lelet Plateau and to a lesser degree north of the Lelet Plateau.

The quantity and quality of cave habitats ultimately influence the density of the local cave roosting Chiroptera populations. If the human population relied on the *Dobsonia* sp. as their primary terrestrial prey taxa as described in Chapter 6, then it might be expected that there were greater density populations around and south of the Lelet Plateau rather than north of it prior to the introduction of the *P. orientalis* into the diet at 20,000 bp. The evidence presented above suggests that small highly mobile groups of Chiroptera hunters moved from cave to cave in search of bat colonies and exploited the nearby littoral resources only as a secondary resource. caves were important nodes on the landscape because they had the potential to contain high protein value resource patches separated by tropical rainforest containing a relatively depauperate fauna.

The period from 20,000 bp to 17,000 bp broadly followed the model described for the previous period with two important changes. First, the appearance of *P. orientalis* signalled a change in resource use, hunting strategies, land use and mobility. *P. orientalis* was not a dominant part of the Unit 3 faunal assemblage but suggested that hunters were beginning to spend more time hunting in the rainforest compared to Unit 4. As described in Chapter 2 the appearance of West New Britain obsidian suggested that central and southern New Ireland inhabitants had either direct or indirect connections through trade or exchange networks with the source area (see Appendix 11), signalling the beginning of an economic and probably social interaction sphere (Allen and Gosden 1996). While the majority of the Matenbek obsidian originated from Mopir (Summerhayes and Allen 1993), the results in Appendix 11 indicate that a majority of the Buang Merabak obsidian originated from Talasea. The different source suggests the potential for a different set of cultural links from each of the sources. This can only be verified by future research.

Unit 2 signifies an important change in resource use and thus hunting strategies, land use and mobility. *P. orientalis* was the dominant prey taxon and *Dobsonia* sp. was relegated to a distant second in the Buang Merabak faunal assemblage. Hunting strategies changed from the pursuit of the high-density cave-dwelling *Dobsonia* sp. populations to the relatively low-density, forest-dwelling *P. orientalis*. The New Ireland Pleistocene cave sites (Buang Merabak and Matenkupkum) were utilised in a different way. While they remaining places for food consumption they were no longer the primary location for the procurement of protein. The change in diet also had repercussions for land-use. Previously, hunters moved through the landscape to the next resource patch. Subsequently, the forest took over as the primary zone of protein procurement thereby changing the use of both the cave and the rainforest.

The introduction of *P. orientalis* into the diet reflected an increase in the amount of time spent at each site. The relatively dispersed nature of *P. orientalis* suggests that it would have taken longer (relative to the *Dobsonia* sp.) to deplete the population in each area. The relatively longer resource exploitation time translates into relatively longer residence time at the cave and an increase in hunting mobility.

Also by 15,000 bp there is evidence of increased utilisation of northern New Ireland (Marshall and Allen 1991; White et al. 1991) to the extent that it became archaeologically visible. This may have been a result of the change in diet in preference to rainforest dwelling protein resources over cave resources as reflected at Buang Merabak. The capture of *Dobsonia* sp. was largely dependant upon the presence of caves that were relatively less prevalent in the north. *P. orientalis* was relatively equally distributed throughout all of the New Ireland forests and its availability after 20,000 bp enabled populations to more intensively utilise areas that were previously resource poor. In some respects this interpretation supports and goes some way to explain the observation by Allen et al. (1989:557) and others (Enright and Gosden 1992:175) that the differences between the northern sites and the southern sites reflect different regional histories.

This period also sees the utilisation of the *T. browni* that was prevalent in northern New Ireland but not southern or central New Ireland. This may be because the relatively flat topography in the north compared to the south favours the success of the chase strategy of prey capture (Bulmer 1968), while in central and southern New Ireland the steep and rugged topography favours the agile assailant.

The Unit 1 interpretation differs from the others because during the previous units the only subsistence strategy in New Ireland was hunting and gathering. Unit 1 coincides with evidence of Late-Lapita at Lasigi (Golson 1991) and elsewhere in the circum-New Ireland region (Egloff et al. 1980; Summerhayes 2000; Spriggs 1997) indicate an additional concurrent agricultural subsistence economy. In this context, if the evidence from Buang Merabak reflecting hunter/gatherer behavior changed in Unit 1, then it might be argued to be a reflection of the impact of agriculture changing the way that populations use the forest. If the Buang Merabak data did not change then this might be interpreted as representing little change in the hunter/gatherer behavior irrespective of the introduction of agriculture into the nearby newly established village of Lasigi.

Overall the Unit 1 assemblage indicates that the impact of Lapita agriculturalists at Lasigi had some impact on behavior at Buang Merabak as evidenced by the presence of a *S. scrofa* tooth fragment. However, overall the impact was limited.

4. REGIONAL OVERVIEW

The New Ireland model of faunal exploitation was considered in conjunction with previous results from New Britain, Bougainville and Manus Islands keeping in mind they were based on different data sets reflecting different aspects of prehistoric human behavior. What follows primarily reflects issues associated with land-use and mobility.

4.2 Colonization

Colonization can be conceptualised in a number of ways. For eastern Polynesia it has been viewed from a social perspective (based on the notion that 'knowledge is power' (Bacon)), whereby it was controlled by those with specialist navigation knowledge. This was predicated on the idea that voyaging across the horizon requires specialised skills and knowledge that translates into social authority (Thomas 2001). Both the Vitiaz Strait (between New Guinea and New Britain) and the St. Georges Channel (between New Britain and New Ireland) sea crossings were characterised by two-way inter-visibility. They required a minimal technological and a limited intellectual barrier to human expansion into New Ireland (Irwin 1994), suggesting utilitarian explanations maybe more applicable. The following discussion focuses on the practical and economic issue of resource availability as the major constraint to New Ireland colonization.

The colonization of a region or an island is difficult to identify in the archaeological record because material commonly forms a palimpsest making the identification of single events beyond the scope of most sites. In this dissertation the data representing colonization are taken to include only the first Unit (4) of occupation at the site and therefore any conclusions are necessarily general in nature. This section begins by discussing the nature of resource use, hunting, land use and mobility before drawing the evidence together in a discussion about colonization.

The results in Chapters 4 and 5 suggest the human colonisers were familiar with the New Ireland rainforest fauna, therefore reducing the relative importance of littoral resources in modelling colonization. The initial colonization of New Ireland reflected low-level predation by small mobile groups of broad-spectrum foragers of the coastal and inland resources (Allen et al. 1989:558).

The nature of the archaeological record and the methods of data collection and analysis are fundamental to the way in which colonization was understood. Some scenarios are easier to verify than others depending on the available evidence. For instance, it was assumed, *a priori*, that boats were a necessary part of the material culture required in the colonization of New Ireland. While the boats themselves have not been identified in the archaeological record their use was central to the Strandlooper model of colonization. The Strandlooper model extends the use of marine technology as the primary means of transport. Alternatively, boats may have simply been utilised to cross a body of water at its shortest distance. Chappell (2000:88) notes that the colonization of New Ireland could have been accomplished on foot aside from two necessary but brief sea crossing and from a transport perspective he was correct. However, the strandlooper model was not only based on the requirement for colonists to cross the sea. The model fits well with a number of aspects of the archaeological record in addition to transport. The high density of coastal archaeological sites contain relative dense middens reflects the use of littoral resources (Balean 1989; Robertson 1986).

Circumstantial (to New Ireland) evidence from New Britain and further a field in Sahul provides examples in which the human occupation of the littoral environmental zone may have provided far fewer resources than previously envisaged. Chappell (2000:91) notes that from a chronological perspective the occupation of coastal sites lags behind the occupation of savannah lands. Elsewhere, it has been strongly argued that the exploitation of littoral resources did not necessarily equate with coastal occupation (Hallam 1987). The following was an investigation into resource-use in order to determine the relative use of specific environmental zones as a reflection of adaptation during and subsequent to colonization.

4.2.2 Protein Acquisition: Forest and Coastal Resources

Previously analyzes have placed emphasis on the exploitation of coastal resources although importantly, forest resources have never been discounted (Allen et al. 1988:707; Balean 1989; Enright and Gosden 1992:175 and Robertson 1986). It has also been argued that plant foods and coastal resources would have provided a majority of people's diet (Gosden 1993:131).

The ethnographic literature suggests that both inland and coastal people obtain carbohydrate from their respective gardens (Clay 1977; Powdermaker 1971 [1933]) and implies that the distinction reflects village location and perhaps their respective access to protein resources. Bush people commonly had direct access to bush animals while the coastal people had direct access to the littoral resources (Roe 2000:201). The resources themselves were not primarily identified as belonging to the inland or coastal environmental zones but rather to the people who exploit and control them (Roe 2000:204). The inland/coastal division might best be made on the grounds of resource use rather than by explicit boundaries or zones (Roe 2000:208). Roe (2000:219) suggests that models that map resources to people might better equip archaeologists to explore notions of change over time. For the purposes of this dissertation the division is drawn on the basis of the spatial distribution of the resources as an indicator of human land use.

Coastal resources were exploited in the oldest cultural layers at Matenkupkum (Robertson 1986) and Buang Merabak (Balean 1989; Leavesley and Allen 1998). At the former, the MNI of *Turbo* sp. shells was 31 and contributes 34% of the shells in the layer (Robertson 1986) spanning 14,000 ^{14}C years. Gosden and Robertson (1991) point out that the cave deposit probably only represents what was a relatively small part of human behavior and that the shells probably only represent a small portion of those consumed by humans. Equally, human hunters were also known to consume part of their catch in the bush prior to returning to the village (Binford 1980) and therefore this rationale can be applied to all resources represented in an archaeological assemblage.

Unit 4 also contained evidence of the exploitation of a small quantity (Allen et al. 1988:552) of reef fish (Allen et al. 1989:1989:552; Robertson 1986:79). They required neither specialised technology nor deliberate pursuit (Allen 1993:144) but rather netting, spearing or poisoning (Allen et al 1989:552). The Buang Merabak assemblage contained bones of the family Thunnidae in Unit 4 indicating a human connection with pelagic resources. It contained a NISP of 1 with a total of 25 documented throughout both TP1A and TP1B (Appendix 6). A quantity of *Carcharhinus* sp. has also been identified in Unit 4. Elsewhere the presence of shark in the assemblage has been interpreted as indicating the utilisation of pelagic resources (White et al. 1991:54) and the same principle is followed here. This suggests first, that while both littoral and pelagic fish were present in the diet they did not constitute a major part of it and secondly, the low NISP indicates very little about the availability of the requisite fishing technologies because their capture may have been fortuitous rather than the product of design. Fish were a small part of the assemblage.

Fish and shellfish were an important part of the diet and were the basis for the interpretations of the Bismarck Archipelago colonists as tropical coastal hunter-gatherers (Allen 2000:148). For Matenkupkum the shellfish and bone were compared on the basis of weight (Robertson 1996:74). Shellfish are highly visible in archaeological record although they have a relatively low meat weight to total animal weight compared to mammals. Therefore a large quantity of shells did not necessarily equate with dominance in the diet (Spriggs 2000:293).

The dominance of the *Dobsonia* sp. as represented by figures 10 and 11 has important implications for New Ireland colonization. The investigations into colonization that stemmed from Matenkupkum (Robertson 1985) focussed on the relatively large quantities of marine shell and therefore asserted the importance of marine shell in the human diet with little investigation into the faunal assemblage. These data provide a better understanding of the quantity of *Dobsonia* sp. and facilitate a comparison with the marine shell. Importantly, even though Buang Merabak was located 200 m from the present coast, the rainforest resources were clearly of equal, if not greater, importance than marine resources to the human diet.

The *Dobsonia* sp. was interpreted as a rainforest resource because their exploitation is not dependant upon the coastal location of Buang Merabak. Once the human predators were familiar with the fact that the spatial distribution of *Dobsonia* sp. was dependant upon the locations of caves and not the association with the coast, then the forests took on a new importance as a protein resource. This suggests two allied possibilities: first, prehistoric hunters preferred littoral zone protein resources and utilised the cave-based resources only in coastally-located caves, or secondly, that the dominance of the *Dobsonia* sp. in the Buang Merabak assemblage represents a wider preference for forest based protein resources over the littoral zone protein resources. If the ratio of 3:1 *Dobsonia* sp. to shell as represented by meat weight is taken as a proxy for the time scheduling for hunting, as it relates to consumption at Buang Merabak, then the data suggest that hunters spent twice as much time hunting in the forests than on the coast.

This is indirectly supported by the utilisation of other inland resources such as Aves (Steadman et al.1999) and the utilisation of inland stone raw material resources at Yombon (1999). These are interpreted as suggesting at least short-term forays into the inland regions of New Britain and New Ireland during the Pleistocene (Pavlides and Gosden 1994). The use of the inland forest is also consistent with arboriculture (Gosden 1995:814; Spriggs 2000). It might also be suggested that there is no particular division or break between the colonization of the coastal and inland regions.

4.2.3 Protein Acquisition: Forest and Coastal Resources-Summary

The evidence presented here suggests that more emphasis ought to be placed on the role of forest resources than previously envisaged. While coastal resources are important, so too was the consumption of the *Dobsonia sp.* that were most likely captured in caves and by extrapolation the forest. Precisely how far into the forest people looked for caves is as yet unknown. Suffice to say that once the connection between caves and protein was made, there was little cause for foragers not to spend a great deal of time away from the coast.

4.3 BISMARCK ARCHIPELAGO AND SOLOMON ISLANDS: ADAPTATIONS

Once colonization began, people had to adapt to the new similar but subtly different island environments in the Bismarck Archipelago. In New Britain adaptation has been investigated in relation to stone tool production. Yombon had a basal Unit spanning the period 35,000 bp to 12,000 bp containing 29 stone artefacts. It reflects initial low-density populations (Pavlides 1999:212) and high residential mobility (Pavlides 1999:393). It also reflects the use of inland resources. As Pavlides states, “it may not have been possible to sustain a large population for long periods of time in the lowland tropical rainforest. Reliance on wild resources may have only been possible with low population densities. Thus it was argued that "the environmental constraints of the lowland rainforest zone necessitate a dispersed residence pattern as well as a limited population" (Pavlides 1999:172). Unlike Buang Merabak and Matenkupkum, the Yombon data indicate the targeting and selection of stone from primary geological contexts during the Pleistocene. The stone artefacts do not reflect any specialisation or standardisation, with high variability in stone resource material and low-levels of planning in terms of stone exploitation and tool design (Pavlides 1999:154-55). Yombon contained one artefact described as a possible type. Future research will duplicate the form or provide evidence of a uniform reduction sequence and substantiate the claim. There is also plant residue on artefacts (Pavlides 1999:212). The evidence from the Buang Merabak faunal assemblage also suggests that the Pleistocene occupants of New Britain and New Ireland consisted of small groups of highly mobile hunter/gatherers. In Unit 4 deposition rates are relatively low suggesting low intensity use of the site. The nature of the protein resources that were exploited suggests a high degree of mobility between the caves that represented resource patches (see Chapter 6).

Interpretations from both New Britain and New Ireland suggest the exploitation of rainforest resources. At Yombon there is evidence of occasional forays into the rainforest to collect stone resources during the course of other activities (Pavlides 1999:393). The Buang Merabak results indicate that those 'other activities' could have been the hunting of prey such as the *P. orientalis* (and possibly *Petaurus breviceps* in New Britain) or Megapteroptera. While Misisil cave does not contain evidence of occupation until the Pleistocene/Holocene transition, it does indicate the presence of large limestone caves that are the potential habitat of Chiroptera within the New Britain interior (Specht et al. 1980). Evidence from both Yombon and the New Ireland sites suggests the exploitation of a variety of rainforest resources. Future research will determine the extent to which it was systematised.

The first evidence of the occupation of the Solomons Archipelago occurs at 28,000 bp from Kilu Cave on Buka Island (Wickler and Spriggs 1988) and adds two further strands of evidence to the regional picture. Buka Island is 180 km south of Cape St. George (Irwin 1992:23). At Kilu the earliest occupation layers reflect the collection of shellfish and terrestrial prey including Chiroptera, Rodentia, Reptilia and Aves. The Solomons Archipelago generally has a much narrower range of taxa than does New Ireland with the exception of the Rodentia. Pleistocene Buka had the extinct *Solomys Spriggsarum* and possibly extinct *Melomys spechti*. Their presence in the Kilu assemblage suggested that they may prove to have been an important

Pleistocene protein resource for Bougainville with the completion of future archaeological research. At Kilu, Reptilia are the dominant taxa by NISP and weight followed by the Rodentia, with Chiroptera a distant third (Wickler 2001:219). Wickler reported taxa at the level of genus or greater and therefore it is difficult to definitively infer any more specifically than broad ecological zones for the prey taxa. However, Rodentia are commonly identified with terrestrial rainforest habitats and with little association with salt water although they can cope with it in extreme circumstances (Spennemann 1989). Similarly, Varanidae monitors were commonly associated with mangrove environments and also inhabited forests well away from the mangrove zone. The Kilu data were the earliest representation of plant residue on stone tools and were dated to between 28,000 bp and 20,000 bp (Loy et al. 1992), suggesting the use of forest-based plant resources (Spriggs 2000). Evidence from Kilu Cave indicated sporadic use of both forest and coastal resources possibly with a greater emphasis on the forest resources and supplementing the Buang Merabak evidence that forest resources played an important role in Pleistocene protein acquisition.

At 20,000 bp there was significant change in hunter/gatherer behavior. *P. orientalis* appears in the New Ireland diet for the first time but does not dominate the diet until after 14,000 bp. Obsidian is moved from West New Britain to southern New Ireland for the first time (Summerhayes and Allen 1993) and possibly by an alternative route to central New Ireland (Allen 2000:154; Leavesley and Allen 1998; Appendix 11). At Matenbek, in southern New Ireland, there is a significant quantity of obsidian from Mopir and lesser amounts from Kutau (Summerhayes and Allen 1993). Obsidian also made its way as far as central New Ireland at this time (Leavesley 1996:49).

The appearance of obsidian in the Bismarck Archipelago assemblages is indicative of down the line exchange and signals a significant change in resource-use in both New Ireland and New Britain and a widening of interaction spheres (Summerhayes and Allen 1993; Gosden and Allen 1996). Down the line exchange reflects notions of mobile groups acquiring obsidian at one end of their range and transferring it to others at the other end of their range until it is discarded. The Buang Merabak data question the nature of this mechanism of exchange and suggest the potential for complexity within this broad framework. The Buang Merabak obsidian was small and heavily reduced and in this respect does not bear the hallmarks of a raw material that has been traded or exchanged. While the down the line method appears more parsimonious the fragment morphology is closely aligned with what might be expected from an artefact that had a small number of owners who continually curated it until it was discarded. As both interpretations have merit, parsimony suggests a combination of the two. Potentially each participant in the exchange network may have used the obsidian and subjected it to curation prior to passing it on so that the last recipient ended up with a highly worked item. Alternatively, it may have come to the end of the exchange line in its original form and was completely used up by the recipient.

By at least 21,000 bp Manus was occupied for the first time (Fredericksen 1994:58; Fredericksen et al. 1993:149; Minol 2000:25). Manus was equidistant (230 km) from both New Guinea and New Ireland. Its colonization represented a water crossing 60-90 km out of sight of land (Irwin 1992; Fredericksen et al. 1993:151) and the first sea crossing of this distance in the region. The pre-12,000 bp levels at Pamwak contained a relatively low density of bone specimens, probably as a result of various taphonomic processes that were not conducive to their preservation. However, the family Varanidae and small quantities of Chiroptera and Murids were the dominant taxa (Williams 1997). A primary factor in determining distances and range of visibility depends on glacial cycles and regional environments.

Previous analyzes were constructed within an environmental context that considers the LGM as occurring at 18,000 bp for 2000 years. Recent research by Lambeck and Chappell (2001) suggests the impact of the LGM began at 28,000 to 30,000 bp and continued until 10,000 bp. The wettest period occurred at 30-25,000 bp and the driest at 15,000 to 10,000 bp. It was not clear whether it was a gradual event or a series of distinct oscillations. The impact of a longer Last Glacial Maximum on human behavior might be expected to be less pronounced than that of a shorter Last Glacial Maximum. It was represented in sites located at West New Britain's (WNB) north coast and central and southern New Ireland. The WNB evidence is still in the process of both chronological and technological analysis (Torrence et al. 1992) and therefore it is hard to say anything more than that it was present. At Buang Merabak the relatively distinct temporal parameters of Unit 3 did not lend itself easily to interpretation in relation to the longer LGM because it was temporally very short. Therefore, there was little evidence to suggest that climate change is a major factor in human behavior during the Last Glacial Maximum.

4.3.2 Pleistocene- Holocene Transition

The Pleistocene-Holocene transition was represented in a number of sites across the Bismarck and Solomons Archipelagos. The Buang Merabak Unit 2 and 1 result indicate a high degree in specialisation in the pursuit of *P. orientalis*. In New Britain, the specific selection of high quality stone resources was interpreted as representing low intensity, high residential mobility by small groups of people that forage over large areas of the landscape in which the procurement of stone resources was embedded in other activities (Pavlides 1999:395; Torrence 1992:120). While the interpretations might be considered as complimentary, especially the idea of the stone resources procurement potentially embedded in behavior dictated by the vagaries of *P. orientalis* hunting, additional data from New Ireland highlight some other issues. For instance the Matenkupkum stone artefact assemblage was defined as amorphous and lacking any complex structure of production (Freslov 1989) and it was therefore in apparent contradiction with the WNB interpretations suggesting regional differences in behavior.

In New Ireland the transition marks the greatest density of deposit in all the sites with evidence of occupation (Leavesley and Allen 1998). The pre-LGM sites of New Ireland, New Britain and Buka were all re-occupied and new sites were occupied for the first time (Leavesley and Allen 1998).

In New Britain, the distribution of obsidian in the Talasea area was dictated by differing access to obsidian sources caused by volcanic activity in the region combined with the ease of access by boat. The organisation of stone procurement around the Talasea obsidian sources and the production of composite stemmed tools of chert and obsidian (Pavlides 1999:395) indicate extensive mobility linked to non-intensive food management strategies (Torrence 1992:113-121; Torrence et al. 2000). In the inland rainforests at Yombon there is also a major re-organisation of stone working activities (Pavlides 1999).

At Pamwak, obsidian from Pam Island appears suddenly and replaces chert within a short space of time, reflecting a clear change in resource use, land use and mobility. While the chert quarry was at present unknown, it was commonly associated with limestone and therefore could easily be relatively proximate. By contrast, the obsidian originates at Pam Island which was 50 km south across the sea from Pamwak and was not the nearest obsidian source. It also represents a social connection that reflects changing mobility patterns. Whether this suggest movement of people to the source or vice versa remains unclear (see Roe 2000 for the options). It also indicates the first evidence of specialised trade or exchange in the Admiralty Islands (Fredericksen 1994:196).

Also at Pamwak, *Echymipera kalubu* appears for the first time at 12,000 bp and *Spilocuscus kraemeri* occurred soon after at 11,500 bp. They are important because they, particularly *E. kalubu,* subsequently become the major focus of the Pamwak diet. *E. kalubu* was not extant in New Ireland and *S. kraemeri* was thought to be a recent introduction (White et al. 1991) and neither has been identified in the prehistoric assemblages. This suggested that they originated from New Guinea and reflected interaction between New Guinea and Manus directly (Williams 1997:94-95).

The Pleistocene-Holocene transition was a time of change across both the Bismarck and Solomon Archipelagos. In New Ireland and New Britain there was a reorganisation of resource use and mobility. In Manus, there was a renewed or a strengthening of connections with New Guinea through the introduction of new prey into the diet.

During the Holocene in New Ireland, *T. browni* first appears in the diet at 8000 bp and was particularly significant in the northern site of Balof 2 (White et al. 1991). *T. browni* hunting strategies were greatly affected by terrain because they commonly involve a chase (Bulmer 1968). The relatively less rugged nature of northern New Ireland gave hunters in the region the greatest strategic advantage (see Chapter 7) and therefore the taxa were more common in the diet at this time. At a broadly similar time on Manus (7000 bp to 3500 bp) there was a significant change in obsidian source use at Pamwak. The use of source X gave way to Lou and Pam Islands material (Fredericksen 1994:174). It reflected changing land use in that different sources were located in different places on the landscape. However, mobility was little changed because source X was also thought to be on Pam Island.

4.3.3 Mid to Late- Holocene

During the Mid-Holocene Pre-Lapita period behaviors in New Ireland and New Britain were markedly different primarily due to the differential impact of vulcanism on each of the Islands. In New Britain the impact on human behavior was relatively extensive compared to New Ireland where volcanism was less catastrophic (although not likely to have been absent).

The Lapita period brought large scale change with the introduction of agriculture and utilitarian and other clay pots. The onset of agriculture in the region, concurrent with Unit 1, provided a different subsistence backdrop to previous Units. At Buang Merabak there was little evidence of the impact of agriculture on the hunter/gatherer populations that periodically inhabited the cave.

Southwest New Britain ethnography indicates that coastal agricultural societies co-existed with neighbours who were the mobile semi sedentary Kaulong and Sengeng who occupied the interior (Goodale 1995 [1926]) reflecting the regional diversity and the potential for quite different regional prehistory's. The New Ireland faunal assemblage indicates little change between Units 2 and 1 suggesting similar hunting practices occurred during both periods accepting that quite different activities may have been occurring at nearby Lasigi village.

5. FUTURE DIRECTIONS

The purpose of this dissertation was to provide balance to the previous models of Pleistocene behavior that placed emphasis on the littoral resources (*cf.* Bailey and Milner 2002). By collecting data representative of a wider range of protein resources the overall pattern of human hunting behavior appeared to be much more evenly divided across a variety of environments across the coastal inland division. In order to expand this research an investigation into Pleistocene hunting in Bougainville, New Britain and New Guinea would be instructive.

Bougainville is an exciting prospect because it has Pleistocene occupation (Wickler 2001) but clearly has a much reduced fauna compared to New Ireland. The Bougainville fauna contains two large now extinct Rodentia (Flannery and Wickler 1990) and did not have any Phalangerids until after the Lapita period. This allows for the opportunity to investigate whether the Megapteroptera played a similar role in the Bougainville Pleistocene as they did in New Ireland or whether the extinct Rodentia had a major impact on the diet during this time.

In New Britain, research could be expanded into investigating the use of the inland caves, particularly those likely to have contained Chiroptera colonies in the past. The inland sites might also supplement important research into the acquisition of various stone resources as is illustrated separately by Torrence (2001) and Pavlides (1999). New Britain has the potential to shed new light on the question of animal translocation. For instance, did the *P. orientalis* arrive in New Britain prior to human occupation or immediately prior to its arrival in New Ireland?

New Guinea also provides an exciting opportunity to expand the line of enquiry expressed in this dissertation. It contains a much wider range of fauna than does the Bismarck Archipelago or the Solomon Islands including megafauna as evidenced at Nombe. The available evidence appears to indicate that both the Phalangerids and Megapteroptera were both important prey taxa even while other taxa are available. Is this a reflection of sampling or is this an indication of predator choice?

New Guinea also provides the opportunity to investigate the role of environmental factors such as altitude on human hunting. Were the first Highlands hunters targeting specific prey taxa such as Megapteroptera on a seasonal basis or is this too a reflection of sampling? Both Bougainville and New Guinea pose important questions in regard to Pleistocene human adaptation particularly as it relates to hunting and provide an opportunity to expand and directly test the ideas proposed above.

The ideas proposed in this dissertation might be tested by investigating New Ireland's inland cave sites in order to determine whether they were in fact utilised by Pleistocene bat hunters. This strategy might also be pursued in the inland areas of New Britain that is the obvious link between New Guinea and New Ireland. Inland sites in Manus might also have a bearing on this interpretation. A strategy might include the targeting of ethnographic hunting caves to determine the extent of their use in the past.

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Appendix 1

Buang Merabak TP1B: pH, and Colour Results.

Spit	Sediment pH.	Munsell colour	Colour	Comment
1	N/A	N/A	N/A	
2	N/A	N/A	N/A	
3	8.5	H2.5Y 3/1	Very dark grey	Clay rich
4	8.5	H10YR 4/2	Dark grey	
5	8.5	H10YR 4/2	Dark greyish brown	
6	8.5	H10YR 4/1	Dark grey	
7	8.5	H10YR 4/1	Dark grey	
8	8.5	H10YR 4/2	Dark greyish brown	
9	8.5	H10YR 4/1	Dark grey	
10	8.5	H10YR 4/1	Dark grey	
11	8.5	H10YR 4/2	Dark greyish brown	
12	8.5	H10YR 3/2	Very dark greyish brown	
13	8.5	H10YR 4/2	Dark greyish brown	
14	8.5	H10YR 4/2	Dark greyish brown	
15	8.5	H10YR 4/2	Dark greyish brown	
16	8.5	H10YR 4/2	Dark greyish brown	
17	8.5	H10YR 4/2	Dark greyish brown	
18	8.5	H10YR 4/2	Dark greyish brown	Lighter to the top
19	9.5-10	H10YR 5/2	Greyish brown	Coarser grain, clay rich
20	10	H10YR 5/2	Greyish brown	small shell fragments
21	10	H10YR 5/2	Greyish brown	
22	10	H10YR 6/2	Light brownish grey	
23	10	H10YR 6/2	Light brownish grey	
24	9	H10YR 6/2	Light brownish grey	
25	10	H2.5Y 6/2	Light brownish grey	
26	9	H2.5Y 5/2	Greyish brown	Lots of roots in this sample
27	10	H10YR 6/2	Light brownish grey	
28	9	H2.5Y 6/2	Light brownish grey	
29	10	H10YR 5/3	Brown	
30	10	H10YR 5/3	Brown	
31	10	H10YR 5/3	Brown	
32	10	H10YR 5/3	Brown	
33	10	H10YR 5/3	Brown	
34	10	H10YR 5/3	Brown	
35	10	H10YR 4/3	Brown	
36	10	H10YR 5/4	Yellowish brown	
37	10	H10YR 5/4	Yellowish brown	
38	10	H10YR 4/4	Dark yellowish brown	Reddish to bottom
39	10	H10YR 4/4	Dark yellowish brown	
40	10	H10YR 4/4	Dark yellowish brown	

Analysis by C. Read (19/04/02).

Appendix 2

Buang Merabak TP1B, Particle Size Analysis Results

Spit	Dry wt. (gm)		>500 m	250m	125m	63m	<63m	Suspension	Total
1			N/A	N/A	N/A	N/A	N/A	N/A	N/A
		%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2			N/A	N/A	N/A	N/A	N/A	N/A	N/A
		%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3			N/A	N/A	N/A	N/A	N/A	N/A	N/A
		%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4			N/A	N/A	N/A	N/A	N/A	N/A	N/A
		%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5			N/A	N/A	N/A	N/A	N/A	N/A	N/A
		%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	183		2.5	24.9	30	29.1	71.8	21.4	179.7
		%	1.39	13.85	16.69	16.19	39.95	11.91	99.98
7	209		40	22	22.2	23.9	39.3	58.2	205.6
		%	19.45	10.71	10.79	11.62	19.11	28.31	99.99
8	139		2.5	20	22.9	21.9	69.9	34.5	171.7
		%	1.45	11.61	13.33	12.75	40.71	20.09	99.94
9	315		58.7	33.9	36.6	40.8	59.9	79.5	309.4
		%	18.97	10.95	11.82	13.18	19.36	25.69	99.97
10	256		50	26.2	26.1	24.5	30.8	89.8	247.4
		%	20.21	10.59	10.54	9.91	12.44	36.29	99.98
11	43		14.1	4.1	3.3	3.4	3.2	12.2	40.3
		%	34.98	10.17	8.18	8.43	7.94	30.27	99.97
12	37		1	3.6	4.7	5.3	8.2	12.9	35.7
		%	2.8	10.08	13.16	14.48	22.96	36.13	99.64
13	245		0.8	30.2	36	49.9	105.9	16.4	239.2
		%	0.34	12.62	15.05	20.86	44.27	6.85	99.99
14	138		19	14.9	15.9	16	24.4	43.8	134
		%	14.17	11.11	11.86	11.94	18.21	32.68	99.97
15	97		14.1	13.7	11.4	11	17.5	28.1	95.8
		%	14.71	14.31	11.89	11.48	18.26	29.33	99.98
16	243		31.8	24	27.1	27.2	42	85.8	237.9
		%	13.36	10.08	11.39	11.43	17.65	36.06	99.97
17	238		12.5	23.7	28.3	32.4	90.9	49.9	237.7
		%	5.25	9.97	11.91	13.63	38.24	20.99	99.99
18	291		16.6	33.6	38.4	63	106.9	23.9	282.4
		%	5.87	11.89	13.59	22.3	37.85	8.46	99.96
19	238		27.7	27.9	33.1	45.7	78.9	22.6	235.9
		%	11.74	11.82	14.03	19.37	33.44	9.58	99.98
20	164		15.8	14.2	17.1	13.1	6.8	95	162
		%	9.75	8.76	10.55	8.08	4.19	58.64	100.17
21	245		22.4	24.7	31.3	37.9	48.6	79.9	244.8
		%	9.15	10.08	12.78	15.48	19.85	32.63	99.97

22	153		14.9	17.2	18	17	41.8	40	148.9
		%	10.01	11.55	12.08	11.41	28.07	26.86	99.98
23	330		34.3	37.7	47.6	65.7	48.1	93.5	326.9
		%	10.49	11.53	14.56	20.09	14.71	28.6	99.98
24	293		21.3	44.1	40.9	43.6	105.9	37.2	293
		%	7.26	15.05	13.95	14.88	36.14	12.72	100
25	234		20.9	18.6	25.2	31.4	51.9	79.5	227.5
		%	9.18	8.17	11.07	13.8	22.81	34.94	99.97
26	252		41.2	42.3	38.7	41.8	62.9	21.4	248.3
		%	16.59	17.03	15.58	16.83	25.33	8.61	99.97
27	276		50.5	38.2	38.6	42.9	66.7	36.2	273.1
		%	18.49	13.98	14.13	15.7	24.42	13.25	99.97
28	156		8.5	12.2	17	20.2	39.6	53.1	98.5
		%	5.44	7.82	10.89	12.9	25.38	34.03	96.46
29A	130		27.8	17.4	14	13.5	37.9	16.6	127.2
		%	21.85	13.67	11.01	10.61	27.79	13.05	97.98
29B	103		16.1	9.7	11.9	12.1	18.1	30.8	98.7
		%	16.31	9.82	12.09	12.25	18.33	31.2	100
30	164		9.9	15.7	21.8	27.2	57.1	26.5	158.2
		%	6.25	9.92	13.78	17.19	36.09	16.75	99.95
31	163		8.2	14.7	21.5	25.7	55	32.5	157.6
		%	5.2	9.32	13.64	16.3	34.89	20.62	99.97
32	225		33.3	35.7	30.7	38.3	71.6	11.6	221.2
		%	15.05	16.13	13.87	17.31	32.36	5.24	99.96
33	230		27.8	27.1	37.8	52.8	38.1	47.4	231
		%	12.03	11.73	16.36	22.85	16.49	20.51	99.97
34	335		43.9	121.4	80.2	26.3	10.2	61.6	343.6
		%	12.77	35.33	23.34	7.65	2.96	17.92	99.97
35	142.7		25.9	30.25	30.7	28.6	27.3	1	142.7
		%	18.149	21.198	21.513	20.042	19.131	0.7	100.033
36	112		14.9	17.1	21.8	21.3	14.7	17.8	107.6
		%	13.84	15.89	20.05	19.7	13.66	16.54	99.66
37	197		32.9	41.4	53.1	32.4	4.7	41	205.5
		%	16.01	20.14	25.83	15.76	2.28	19.95	99.97
38	120.56		0.42	31.85	35.68	28.18	24.43	1	120.56
		%	0.348	26.418	29.595	23.374	20.263	0.82	100
39	123.49		32	27.4	27.09	20.4	16.6	1	123.49
		%	25.91	22.188	21.936	16.51	13.44	0.8	100
40	10		N/A	N/A	N/A	N/A	N/A	N/A	N/A
		%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	6830.75								

Matthew Leavesley and Caroline Read

Appendix 3

Buang Merabak TP1B, XRD data.

Minerals	Spit 12		Spit 15		Spit 23		Spit 33		Spit 40	
	Wt. %	Error	Wt. %	Error	Wt. %	Error	Wt. %	Error	Wt. %	Error
Calcite	82.082	0.6	82.582	0.55	81.8818	0.69	83.3833	0.49	42.7427	0.55
Apatite	6.565	0.24	9.494	0.3	10.4104	0.38	10.01	0.27	13.9139	0.31
Aragonite	3.939	0.29	3.434	0.24	1.717	0.31	0.808	0.22	0.3636	0.35
Quartzite	0.202	0.13	0.303	0.11	0.303	0.14	0.202	0.1	0.606	0.15
Kaolinite	1.818	0.26	0.808	0.22	0.909	0.27	1.01	0.19	14.7147	0.77
Muscovite	5.353	0.48	2.626	0.4	3.131	0.51	3.333	0.36	8.383	0.57
Biotite	0.303	0.2	0.303	0.16	0.505	0.21	0.303	0.14	0.707	0.23
Magnetite	0	0	0.808	0.12	1.313	0.15	1.111	0.1	4.646	0.17
Woodhouseite	0	0	0	0	0	0	0	0	10.9109	0.31

Error 2.5%

The XRD analysis was undertaken by Robin Westacott and Belinda Crowther of the Department of Geology, ANU.

Appendix 4

Recording Forms

Buang Merabak fauna

Idnumber: 5316

Test pit:

Spit:

Strat. Unit:

Date:

Number of specimens:

Weight:

Species:

Body part:

Element:

Common name:

Broken? ☐

% present:

☐ Complete

Calcification (%):

Symmetry:

Height:

Length:

Width:

☐ Photo?

Comment:

☐ Unknown bone

☐ Small animal ☐ Medium animal ☐ Large animal

Dentitions, mandibles & maxillae

Idnumber: 5316

Mandible height:

☐ Mandible ☐ Maxillae

☐ Symthisis ☐ Mental foramen (2

landible

☐ Mental protuberance ☐ Mental foramen ☐ Mental spine ☐ Anterior ramus of dentary

☐ Posterior ramus of dentary ☐ Angular process ☐ Condyle ☐ Coronoid process ☐ Vertical ramus

☐ I1 Alveola ☐ I2 Alveola ☐ C1 Alveola

☐ P1 Alveola ☐ P2 Alveola ☐ P3 Alveola ☐ P4 Alveola

☐ M1 Alveola ☐ M2 Alveola ☐ M3 Alveola ☐ M4 Alveola ☐ M5 Alveola ☐ M5 fully erupted

☐ I1 Alveola (2 ☐ I2 Alveola (2 ☐ C Alveola (2 ☐ P1 Alveola (2

eth

☐ Cusp? ☐ Root?

☐ Incisor(s) ☐ Canine

Alveola:

☐ Pre-molar 1 ☐ Pre-molar 2 ☐ Pre-molar 3 ☐ Pre-molar 4

☐ Molar 1 ☐ Molar 2 ☐ Molar 3 ☐ Molar 4 ☐ Molar 5

unknown teeth:

Maxilla

Phalanger orientalis

M1-M3	P3-M3	M1-M2
P3-M4	M1-M4	M3-M4

achrymal ☐ Lachrymal canal ☐ Infraorbital forame ☐ Jugal

quamosal ☐ Palatine ☐ Palatine foramen ☐ Maxilla ☐ Premaxilla

☐ Upper I1alveola ☐ Upper C alveola

☐ Upper P3 alveola ☐ Upper P4 alveola

# of unknown upper alveola:

☐ Alveola, r. of dentary paralle

☐ Upper M1 alveola ☐ Upper M2 alveola

Tooth wear:

☐ Upper M3 alveola ☐ Upper M4 alveola

☐ Upper M5 alveola

Total height:

Enamel height:

Tooth length:

Tooth width:

Age:

Root height:

Root length:

Root width:

Crenellations:

Cutting edges:

Enamel colour:

cranial sub-elements:

Head

☐ Nasal ☐ Orbit (left) ☐ Orbit (right) ☐ Frontal ☐ Parietal (right) ☐ Parietal (left)

☐ Transverse crest ☐ Sagittal crest ☐ Occipital condyle

☐ Brain cavity (prox.) ☐ Brain cavity (distal)

Axial

Idnumber
5316

☐ Vertebrae

Vertebrae

☐ Atlas ☐ Axis ☐ Cervica ☐ Thoracic ☐ Lumbar ☐ Sacral ☐ Sacrum ☐ Caudal ☐ Vert unknown

Vert Sub-element portion

☐ Ant. neural spine
☐ Ant. centrum
☐ Left anapophysis ☐ Right Anapophysis
☐ Post. centrum
☐ Left metapophysis ☐ Right metapophysis
☐ Post. neural spine
☐ Left transverse process ☐ Right transverse process

Ribs ☐ Rib

☐ Rib head ☐ Rib neck ☐ Rib tubercle ☐ Rib angle ☐ Rib body ☐ Rib sternal end

Reptiles

☐ Rib anteroventral process ☐ Rib articular facet ☐ Rib posterodorsal process

☐ Sternum

Clavicle

☐ Clav sternal shaft
☐ Clav sternal facet ☐ Clav mid shaft ☐ Clav conoid tubercle ☐ Clav acromial facet
☐ Clav acromial shaft

axial sub-elements

Girdle

Idnumber

5316

☐ Girdle

☐ Pelvis ☐ Scapula

Scapula

☐ Sc Supraspinous process

☐ Sc Scapula fossa

☐ Sc Lateral angle ☐ Sc Anterior spine ☐ Sc Posterior spine ☐ Sc Vertebral border

☐ Sc Acromion process

☐ Sc Infraspinous process

Pelvis

☐ Pe acetabulum notch

☐ Pe auricular surface ☐ Pe iliac crest ☐ Ilium ☐ Acetabulum ☐ Ischium ☐ Pe Ischium fossa

☐ Pubis

☐ Sternum

girdle sub-elements

Long bones

Idnumber
5316

No. of epyphisal ends present ______
No. of epiphyses attached ______
Attached epiphysis ______

Humerus

☐ Head humerus
☐ Anatomical neck
☐ Greater tuberosity ☐ Lesser tuberosity
☐ Surgical neck
☐ Unknown diaphysis
☐ Prox diaphysis
☐ Mid diaphysis
☐ Hu Gtr tuberosity crest
☐ Dist diaphysis
☐ Distal diaphysal bend
☐ Hu foramer
☐ Medial epicondyle ☐ Lateral epicondylar ridge
☐ Ulnar groove
☐ Coronoid fossa ☐ Radial fossa
☐ Trochlea ☐ Capitulum

Radius

☐ Ra head
☐ Radial tuberosity
☐ Ra prox diaphysis
☐ Ra mid diaphysis
☐ Ra dist disphysis
☐ Ra ulnar notch ☐ Ra carpal articular surface

Femur

☐ Femur head
☐ Femur neck
☐ Greater trochanter ☐ Lesser trochanter
☐ Fe prox diaphysis
☐ Fe mid diaphysis
☐ Fe dist diaphysis
☐ Popliteal surface
☐ Fe medial epicondyle ☐ Fe lateral epicondyle
☐ Fe medial condyle ☐ Fe lateral condyle

Fibula

☐ Fi head epyphysis
☐ Fi head
☐ Fi prox diaphysis
☐ Fi mid diaphysis
☐ Fi dist diaphysis
☐ Fi dist surface
☐ Fi dist epyphysis

Tibia

☐ Ti prox epyphysis
☐ Tibial tuberosity
☐ Ti interosseous margin
☐ Ti prox diaphysis
☐ Ti mid diaphysis
☐ Ti dist diaphysis
☐ Ti fibula notch
☐ Ti medial malleolus

Ulnar

☐ Ul Head
☐ Ul olecranon proces
☐ Ul trochlear notch
☐ Ul coronoid process
☐ Ul radial notch
☐ Ul prox diaphysis
☐ Ul mid diaphysis
☐ Ul dist diaphysis
☐ Ul articular circumference
☐ Styloid process

long bone elements ______

☐ Tarsals/carpals ☐ Phalanges

Fractures

tures per specimen

5316

ture location 1

Fracture angle (L1)

Fracture outline (L1)

Fracture surface colour (L1)

ture surface texture (L1)

Fracture length

☐ L1 calcified

☐ l1 flaking

L1 flaking location

Fracture type (L1)

☐ Green (L1) ☐ Old dry break (L1) ☐ Recent dry break (L1)

ture location 2

Fracture angle (L2)

Fracture outline (L2)

Fracture surface colour (L2)

ture surface texture (L2)

Fracture length (L2)

☐ L2 calcified?

☐ L2 flaking

L2 flaking lcoation

Fracture type (L2)

☐ Green (L2) ☐ Old dry break (L2) ☐ Recent dry break (L2)

ture location 3

Fracture angle (L3)

Fracture outline (L3)

Fracture surface colour (L3)

Fracture surface texture (L3)

ture length (L3)

☐ L3 calcified?

☐ L3 flaking

L3 flaking location

Fracture type (L3)

☐ Green (L3) ☐ Old dry break (L3) ☐ Recent dry break (L3)

ture location 4

Fracture angle (L4)

Fracture outline (L4)

Fracture surface colour (L4)

ture surface texture (L4)

Fracture length (L4)

☐ L4 calcified?

☐ L4 flaking

L4 flaking location

☐ Green (L4) ☐ Old dry break (L4) ☐ Recent dry break (L4)

Buang Merabak Bone Damage

Idnumber: 5316

Cutmarks

Cutmarks no.:
Cutmark location 1:
Cutmark kind (L1):
Cutmark kind 1:
Cutmark kind (L2):

Puncture marks

Puncture marks No.:
Puncture mark location 1:
Puncture mark location 2:
Puncture kind (L1):

Gnawing

Gnawing no.:
Gnawing location 1:
Gnawing kind (L1):
Gnawing location 2:
Gnawing kind (L2):

Burning

Number burnt:
Burning location:

Furrow (s)

Furrows (#):
Furrows location:
Furrow symmetry:

Crushing

☐ Crushing?
Crushing location:

Root etching

☐ Root etching
Root etching location (L1):

Polish

☐ Polishing
Polish location (L1):
Polish kind (L1):

Calcified conjoin

☐ Calcified conjoir
Cal. con. location:

Conjoin:
☐ Articulated

Danage comments:

Appendix 5

Buang Merabak Chiroptera

Sue Hand
University of New South Wales

These represent the closest approximations I can make based on the limited material available in Australian Museum collections held in Sydney. Studies of intraspecific variation in extant taxa (in larger extant samples) would help refine the identifications.

Id #	Test pit	Spit	Taxa	Comment
32	TP1A	Unit IV W	*Dobsonia* sp.	*cf. D. anderseni* RP_3
46	TP1A	Unit IV W	*cf. D. anderseni*	
87	TP1A	Unit IV S	*Dobsonia* sp.	Range of *D. praedatrix* C^1
23	TP1A	Unit III S	*Hipposideros diadema*	M_3
21	TP1A	Unit III S	*D. praedatrix*	M_{1-2}
50	TP1A	10	*H. diadema*	LM_2
53	TP1A	11	*H. diadema*	RM_3
59	TP1A	11	?	RP_3
?	TP1A	11B	*Dobsonia* sp.	Smaller than *D. anderseni*
54	TP1A	11B	?	Large *Pteropus* sp.
69	TP1A	12	*H. diadema*	M_{2-3}
73	TP1A	12	*Dobsonia* sp.	*cf. D. anderseni* C^1
74	TP1A	12	*Dobsonia* sp.	*cf. D. anderseni* C^1
86	TP1A	12	*Dobsonia* sp.	*cf. D. anderseni*
97	TP1A	12	?	Partial indentulons dentary
98	TP1A	12	*Dobsonia* sp.	Not *D. anderseni*, *D. praedatrix* or *P. magma*. P_4-M_3
104	TP1A	13	*Pteropus* sp.	Large, premolar possibly *P. neohibernicus*
101	TP1A	13	cf. *Nyctimene* sp.	megabat
103	TP1A	13	*Dobsonia* sp.	C^1 not *D. anderseni* or *D. Praedatrix*
112	TP1A	13	*H. diadema*	Rostrum with RP^4, M^3 + LP^4, M^1
114	TP1A	15	*Rousettus* sp.	Very small
115	TP1A	15	*Dobsonia* sp.	RHS, smaller than *D. praedatrix*
118	TP1A	15	*Dobsonia* sp.	*cf. D. anderseni*, C^1
120	TP1A	15	?	Right dentary, P_2-M_3
121	TP1A	15	?	
139	TP1A	16	*Dobsonia* sp.	Different to *D. anderseni* and *D. praedatrix*
137	TP1A	16	?	R dentary, M_{1-3}
146-147	TP1A	17	*Dobsonia* sp.	*cf. D. praedatrix*
154a	TP1A	18	*Dobsonia* sp.	*cf. D. anderseni* P^3-M^1
154b	TP1A	18	*Dobsonia* sp.	*cf. D. praedatrix* M_{1-3}
158	TP1A	19	*Pteropus* sp.	Possibly *P. neohibernicus*
155-162	TP1A	19	3 x *Dobsonia* sp.	*cf. D. anderseni*
	TP1A		1 x *Dobsonia* sp.	*cf. D. praedatrix*
155	TP1A	19	?	Partial edent denatary
?	TP1A	19	*Dobsonia* sp.	*cf. D. praedatrix,* partial dent with M_{2-3}
170	TP1A	19	*Dobsonia* sp.	Partial edent dent, *cf. D. anderseni*
171	TP1A	19	*Dobsonia* sp.	M_2 *cf. D. anderseni*
172	TP1A	19	D. *praedatrix*	
180	TP1A	21	*Dobsonia* sp.	M_{1-2}, size range of *D. praedatrix*

185	TP1A	22	*D. anderseni*	Maxillary specimens with M^3
209	TP1A	22	*D. anderseni*	M^{1-2}
206	TP1A	22	?	Edent dentary specimen
210-213	TP1A	22	?	Isolated teeth
187-189	TP1A	22	*Dobsonia sp.*	Isolated teeth
186	TP1A	22	*Pteropus* sp.	Possibly *P. neohibernicus*
347	TP1A	23	?	Juvenile megabat indent
?	TP1A	23	*N. albiventer*	
190	TP1A	23	?	Edent dentary
195	TP1A	23	*Dobsonia* sp.	M^{1-2}, *cf. D. praedatrix*
196	TP1A	23	?	M_{1-2}
197-198	TP1A	23	?	Megabat canines
?	TP1A	23	?	*cf. Dobsonia* sp.
285	TP1A	23	?	Skull specimen, megabat
255	TP1A	24	*D. anderseni*	Broken P^3
256	TP1A	24	*D. anderseni*	P^4-M_3
257	TP1A	24	*Dobsonia* sp.	*cf. D. praedatrix*
258	TP1A	24	*Dobsonia* sp.	Smaller than *D. anderseni*
259	TP1A	24	*P. neohibernicus*	C_1
260	TP1A	24	*Dobsonia* sp.	C_1
215	TP1A	24	*Dobsonia* sp.	M^{1-2}, similar to *D. anderseni* but different(?)
216-227	TP1A	24	?	Isolated teeth, not larger than *Dobsonia* species
224-234	TP1A	24	?	Dentary specimens, mega indents
236-239	TP1A	24	*Dobsonia* sp.	Canines but not *D. praedatrix, D. anderseni* or *magna*
254	TP1A	24	*P. neohibernicus*	
240-242	TP1A	24	*D. anderseni*	P_3
	TP1A			P^3 different to *D. praedatrix*
	TP1A			P^4 *cf. D. praedatrix*
244	TP1A	24	*Dobsonia* sp.	M^1
245	TP1A	24	*Dobsonia* sp.	M_5
246	TP1A	24	*Dobsonia* sp.	M^1
271	TP1A	25	*Dobsonia* sp.	P^3, *cf. D. anderseni*
264	TP1A	25	*Dobsonia* sp.	M^1, *cf. D. anderseni*
263	TP1A	25	*Dobsonia* sp.	C^1, *cf. D. anderseni*
?	TP1A	27	*Pteropus* sp.	
280	TP1A	27	*Nyctimene* sp.	
272	TP1A	27	*D. praedatrix*	Skull specimen
282	TP1A	27	?	Isolated canine
283	TP1A	27	*P. temmincki*	M_2 and broken M_3
277	TP1A	27	?	Megabat indent
281	TP1A	27	*H. diadema*	Left dentary with I^2-M_3
291	TP1A	29	*D. praedatrix*	M_{1-3}
293	TP1A	29	?	Canine, mega indet
292	TP1A	29	*P. neohibernicus*	Large upper canine
338	TP1A	29	?	Left dentary with M_{2-3}
357	TP1A	34	*Dobsonia* sp.	P_4-M_2
336	TP1A	34	*Dobsonia* sp.	Between *D. anderseni* and *D. praedatrix*
340-342	TP1A	34	*Dobsonia* sp.	M^2, *cf. D. praedatrix*
	TP1A		*Dobsonia* sp.	P_2, *cf. D. anderseni*
	TP1A		*Dobsonia* sp.	M_2, *cf. D. anderseni*
580	TP1A	32	*Dobsonia* sp.	M_{1-3}, *cf. D. anderseni*
573	TP1A	32	*P. temmincki*	
571-572	TP1A	32	*Dobsonia* sp.	

582	TP1A	32	*Dobsonia* sp.	C_1, *cf. D. anderseni*
615	TP1A	34	*Dobsonia* sp.	Similar size to *D. praedatrix*
616	TP1A	34	*Dobsonia* sp.	Anterior specimen, similar to *D. praedatrix*
617	TP1A	34	*Dobsonia* sp.	C_1, smaller than *D. praedatrix*
618-621	TP1A	34	*Dobsonia* sp.	C^1, *cf. D. praedatrix*
	TP1A	34	*Dobsonia* sp.	2 x C_1, between *D. anderseni* and *D. praedatrix*
	TP1A	34	*Dobsonia* sp.	P^4, *cf. D. praedatrix*
339	TP1A	34	*H. diadema*	LM_{2-3}
701	TP1A	37	*D. praedatrix*	M_{1-2}
699	TP1A	37	*Dobsonia* sp.	M_{1-3}, slightly larger than *D. praedatrix*
704	TP1A	37	*Dobsonia* sp.	Maxilla P^3-M^1, between *D. anderseni* and *D. praedatrix*
700	TP1A	37	*Dobsonia* sp.	M_3
706	TP1A	37	*Dobsonia* sp.	P_3, *cf. D. praedatrix*
707	TP1A	37	?	Megabat indet
308	TP1A	34	*P. neohibernicus*	Large
307	TP1A	34	?	Dentary specimen
343	TP1A	34	*Rhinolophus* sp.	C^1
345	TP1A	34	?	*cf. Dobsonia* sp., large canines
306	TP1A	34	*D. praedatrix*	P_4-M_3,
309	TP1A	34	*Dobsonia* sp.	Broken molar, *cf. D. praedatrix*
346	TP1A	34	*Pteropus* sp.	Very large molar, not *P. neohibernicus*
310-312	TP1A	35	?	Edent dentary specimens
321	TP1A	35	*Dobsonia* sp.	Skull specimen, small species
318	TP1A	35	?	Edent dentary specimen.
319	TP1A	35	*Dobsonia* sp.	*cf. D. anderseni*
322	TP1A	35	*Rhinolophus megaphyllus*	M_{1-2}

TPIB Spit 3

#343	Megachiropteran indet.; edentulous left maxillary fragment with zygomatic root
#349	cf. *Dobsonia anderseni;* isolated left M^1

TPIB Spit 4

#350	*Dobsonia* sp. (cf. *D. anderseni*)*;* right C^1

TPIB Spit 5

#351	*Dobsonia* sp. (cf. *D. anderseni*)*;* edentulous posterior dentary fragment with alveoli for M_{1-3}

TPIB Spit 6

#352	Megachiropteran indet. (cf. *Nyctimene* sp.)*;* edentulous anterior dentary fragment with alveoli for right C_1-M_1

TPIB Spit 7

#353	*Dobsonia* sp. (cf. *D. anderseni*); worn first left upper premolar

TPIB Spit 8

#354	*Dobsonia* sp. cf. *D. praedatrix;* right dentary fragment with M_1
#355	*Dobsonia* sp. (large taxon); lower canine

TPIB Spit 8

#356	Megachiropteran indet.; edentulous dentary fragment

TPIB Spit 9

#357-358	Megachiropteran indet. (cf. *Pteropus* sp.); edentulous posterior dentary fragments narrow and flattened

TPIB Spit 10

#359	Megachiropteran indet. (cf. *Dobsonia* sp.); edentulous anterior right dentary fragment with fused symphysis
#360	Megachiropteran indet. (cf. *Dobsonia* sp.); edentulous anterior left dentary fragment with fused symphysis (between *D. anderseni* and *D. praedatrix* in size)

TPIB Spit 11

#362	Megachiropteran indet.; edentulous dentary fragment
#365	*Pteropus* sp.; right M^1; ?cf. *P. temmincki*

TPIB Spit 12

#372	?*Dobsonia* sp.; edentulous right dentary fragment
#373	cf. *Dobsonia praedatrix*; right dentary fragment with P_3
#374	*Dobsonia* sp. (between *praedatrix* and *anderseni* in size); left maxillary fragment with C^1 and first upper premolar

TPIB Spit 13

#375	*Dobsonia anderseni;* left dentary fragment with C_1-P_4
#377	*Dobsonia* sp. cf. D. *anderseni;* left maxillary fragment with P^4-M^1
#378	*Dobsonia anderseni;* left dentary fragment with P_{3-4}
#384	*Dobsonia* sp. (cf. *D. praedatrix*); left upper canine
#385	*Dobsonia anderseni;* left dentary fragment with C_1-M_3

TPIB Spit 13

#383	Megachiropteran indet.; right dentary fragment with worn M_{2-3}

TPIB Spit 14

#390-391	Chiropteran indet.; edentulous dentary fragments
#395-396	Megachiropteran indet.; edentulous dentary fragments

TPIB Spit 14

#392	*Dobsonia anderseni;* isolated right P^4
#397	*Dobsonia anderseni;* right maxillary fragment with M^1

TPIB Spit 14

#393	*Hipposideros diadema;* left dentary fragment with P_4-M_3

TPIB Spit 14

#394	cf. *Rousettus* sp.; right dentary fragment with M_2 (smaller than *R. amplexicaudatus* from PNG)

TPIB Spit 15

#401	*Hipposideros diadema;* left dentary fragment with M_1

TPIB Spit 16	
#405	*Dobsonia* sp. cf. *D. anderseni;* right dentary fragment with M_1
#406	*Dobsonia* sp. (smaller taxon cf. *D. praedatrix*)*;* left dentary fragment with M_3
TPIB Spit 17	
#414-415	cf. *Rousettus* sp.*;* edentulous dentary fragments (smaller than *R. amplexicaudatus* from PNG)
TPIB Spit 17	
#416	*Hipposideros diadema;* left maxillary fragment with P^4-M^3
TPIB Spit 17	
#417	Megachiropteran indet.*;* large upper canine (cf. *Dobsonia magna* size)
TPIB Spit 17	
No number	cf. *Dobsonia* sp.*;* lower canine
TPIB Spit 18	
#423	*Dobsonia anderseni;* left dentary fragment with M_2
#424	*Dobsonia anderseni;* left dentary fragment with P_3 and M_2
TPIB Spit 19	
#430	*Dobsonia* sp. (cf. *D. anderseni*)*;* right upper canine
TPIB Spit 20	
#436	*Dobsonia praedatrix;* right dentary fragment with P_4
TPIB Spit 20	
#457	*Hipposideros diadema;* right posterior dentary fragment with M_{2-3}
TPIB Spit 21	
#440	Megachiropteran indet. (cf. Dobsonia sp.)*;* isolated lower molar
TPIB Spit 21	
#441	*Hipposideros diadema;* right posterior dentary fragment with M_{2-3}
#442	*Hipposideros diadema;* right posterior dentary fragment with M_{1-3}
TPIB Spit 22	
#449	Megachiropteran indet.*;* dentary fragment with M_2
#449-451	*Dobsonia* sp.; isolated canines (1x lower; 2x upper)
#455	*Dobsonia praedatrix*)*;* right maxillary fragment with C^1-M^1
TPIB Spit 23	
#463-	*Dobsonia* sp. indet.; isolated canines x6
TPIB Spit 25	
#484	*Dobsonia* sp. (cf. *D. praedatrix*)*;* left dentary fragment with C_1-M_1
#485	Megachiropteran indet.*;* left dentary fragment (limy crust) with M_2
#487	*Dobsonia* sp. (cf. *D. praedatrix*)*;* right C_1
#488	*Dobsonia* sp. (cf. *D. praedatrix*)*;* left C^1

TPIB Spit 25

#486	Microchiropteran indet.; edentulous right dentary fragment

TPIB Spit 26

#499-500	*Dobsonia* sp. (cf. *D. praedatrix*); left upper canine, right lower canine

TPIB Spit 27

#511	Megachiropteran indet.; left dentary fragment with M_3
#512-513	Megachiropteran indet. (?*Dobsonia*); lower canines x2

TPIB Spit 28

#526	*Dobsonia praedatrix;* left dentary fragment with M_1
#527	Megachiropteran indet.; dentary fragment with fragments of anterior teeth
#528	*Dobsonia praedatrix;* left dentary fragment with M_2 and part of ascending ramus
#529	*Dobsonia* sp. cf. *D. praedatrix;* right maxillary fragment with first upper premolar

TPIB Spit 29

#535	Megachiropteran indet.; right dentary fragment with M_3
#538-542	*Dobsonia* sp.; right C^1
	Dobsonia sp.; right C^1
	Dobsonia sp.; right C^1
	Dobsonia sp. cf. *D. anderseni*; right M_1
	Chiropteran indet.; canine
No number	*Dobsonia* sp. cf. *D. anderseni* (slightly smaller); left dentary fragment with M_2

TPIB Spit 29

#537	*Hipposideros diadema;* left anterior dentary fragment with C_1-M_1

TPIB Spit 30

#553	*Dobsonia anderseni;* left dentary fragment with P_4 and M_3
#555	Megachiropteran indet.; canines x2
#558	Megachiropteran indet.; lower canine broken

TPIB Spit 30

#554	*Hipposideros diadema;* right dentary fragment with C_1-M_2

TPIB Spit 32

#571-572	cf. *Dobsonia* sp.; edentulous dentary fragments x2
#573	cf. Pteropus temmincki; edentulous mandible with fused dentaries
#580	*Dobsonia anderseni;* right dentary fragment with $M_{1\text{-}3}$
#582	*Dobsonia* sp.; left lower canine

TPIB Spit 33

#595	Megachiropteran indet.; right dentary fragment with M_3
#597-599	Megachiropteran indet.; 2x canine fragments
	Dobsonia praedatrix; right anterior upper premolar

TPIB Spit 34

#615	Megachiropteran indet.; edentulous right dentary fragment

#616	*Dobsonia* sp.; edentulous anterior dentary fragment
#617	Megachiropteran indet. (?*Dobsonia*); anterior dentary fragment with C_1 (size cf. *praedatrix*)
#618-621	cf. *Dobsonia* sp. 2 lower canines, 1 upper canine, 1 upper premolar

TPIB Spit 35

#639	Megachiropteran indet.; edentulous dentary fragments
#644	*Dobsonia* sp. cf. *D. praedatrix*; edentulous anterior mandible with fused dentaries
#652	Megachiropteran indet.; left dentary fragment with M_3
#653	Megachiropteran indet.; isolated cheek tooth
	cf. *Dobsonia*; M_2 (cf. *praedatrix*) and canines x2

TPIB Spit 35

#323	*Dobsonia* sp. (not *Rousettus*)*;* left edentulous maxillary fragment
#324	*Dobsonia* sp. (not *Rousettus*)*;* left edentulous maxillary fragment
	both with zygomatic root and infraorbital foramen

TPIB Spit 35

#646	*Dobsonia anderseni;* right dentary fragment with M_2
#647	Megachiropteran indet.*;* right dentary fragment with tooth fragments
#649	*Dobsonia praedatrix;* left dentary fragment with M_1
#650	*Dobsonia praedatrix;* right dentary fragment with M_{1-2} & left dentary fragment with P_4-M_1
#651	*Dobsonia praedatrix;* left dentary fragment with P_2

TPIB Spit 36 (L)

#673	Megachiropteran indet.*;* edentulous left dentary fragment
#674	*Dobsonia anderseni;* right dentary fragment with M_{1-2}
#675	*Dobsonia praedatrix;* left dentary fragment with M_{2-3}
#676	*Dobsonia praedatrix;* left dentary fragment with M_2
#677	Megachiropteran indet. (cf. *D. praedatrix*)*;* left dentary fragment with M_2
#678	*Dobsonia* sp. (cf. *D. praedatrix*)*;* right maxillary fragment with M^1
#679-683	Megachiropteran indet. (cf. *D. praedatrix*); isolated upper and lower canines
#684	*Dobsonia* sp. (cf. *D. praedatrix*); isolated P^4

TPIB Spit 37

# 705	Megachiropteran indet.; very large molar ?*Pteropus*

TPIB Spit 38

#724	*Dobsonia* sp. cf. *D. anderseni;* right dentary fragment with M_2
#725	*Dobsonia praedatrix;* left dentary fragment with M_1 and M_3
#726	*Dobsonia praedatrix;* right dentary fragment with M_2
#727	Megachiropteran indet.*;* dentary fragment with tooth fragment
#728	*Dobsonia praedatrix;* left dentary fragment with M_{1-2}
#730	*Dobsonia* sp. (cf. *D. praedatrix*)*;* left upper canine

TPIB Spit 38

#729	Megachiropteran indet. (?*Pteropus* sp.); right dentary fragment with alveoli for M_2 and M_3; very large (larger than *P. neohibernicus* AM2090 New Ireland, PNG)

TPIB Spit 39

#742	*Dobsonia* sp. (cf. *D. praedatrix*); right dentary fragment with M_{1-2}
#743	Megachiropteran indet.; dentary fragment
#744	*Dobsonia* sp. (cf. *D. praedatrix*); left dentary fragment with M_2
#746	Megachiropteran indet.; lower canine fragment

TPIB Spit 39

#747	Megachiropteran indet. (?*Dobsonia* sp.); very large (larger than *D. molluccensis*)

Appendix 6

Buang Merabak Fish

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Testpit 1B

Spit	**Taxon**	**Element**	**Side**	**NISP**	**MNI**
Spit 7	Scaridae	Premaxilla	Left	1	1
Spit 9	Coridae/Labridae	Inferior Pharyngeal Cluster		1	1
Spit 9	Scaridae	Superior Pharyngeal Cluser	Right	1	1
Spit 10	Lutjanus sp.	Quadrate	Left	1	1
Spit 14	Scaridae	Premaxilla	Left	1	1
Spit 14	Coridae/Labridae	Premaxilla	Right	1	1
Spit 16	Coridae/Labridae	Premaxilla	Left	1	1
Spit 16	Diodon sp.	Dermal Spine		1	1
Spit 22	Balistidae	Tooth		1	1
Spit 34	Thunnidae/Katsuwonid	Vertebrae		1	1
				10	10

MNI by family for TP1B

FamilyName	**MNI**	**%**	
Coridae/Labridae	3	30.0%	Wrasses-sand
Scaridae	3	30.0%	Parrotfish-reef
Balistidae	1	10.0%	Triggerfish
Diodontidae	1	10.0%	Puffers-reef
Lutjanidae	1	10.0%	Snappers-carnivores
Scombridae	1	10.0%	
Total	10		

Tespit 1A

Spit	**Taxon**	**Element**	**Side**	**NISP**	**MNI**	
TP1A	Scaridae	Superior Pharyngeal Cluster	Right	1	1	
Spit 7	Diodon sp.	Premaxilla	Right	1		
		Premaxilla	Left	1	1	
Spit 7	Monotaxis granoculis	Articular	Right	1	1	Big-eye emporer-reef
Spit 7	Scaridae	Dentary	Right	1	1	
Spit 8	Scaridae	Inferior Pharyngeal Cluster		1	1	
Spit 9	Scaridae	Inferior Pharyngeal Cluster		2	2	
Spit 10	Scaridae	Inferior Pharyngeal Cluster		1	1	
Spit 10	Coridae/Labridae	Premaxilla	Right	1	1	
Spit 10	Monotaxis granoculis	Dentary	Right	1	1	
Spit 11	Lutjanus sp.	Quadrate	Left	1	1	
Spit 11B	Lutjanus sp.	Quadrate	Right	1	1	
Spit 11B	Serranidae	Dentary	Right	1	1	
Spit 16	Coridae/Labridae	Dentary	Left	1	1	
Spit 30	Scaridae	Superior Pharyngeal Cluster	Left	1	1	
				16	15	

MNI by family for TP1A

Family Name	**MNI**	**%**	
Scaridae	7	46.7%	
Coridae/Labridae	2	13.3%	
Lutjanidae	2	13.3%	
Nemipteridae	2	13.3%	Bream
Diodontidae	1	6.7%	
Serranidae	1	6.7%	
Total	15		

MNI by family for Buang Merabak

Family Name	**MNI**	**%**
Scaridae	10	40.0%
Coridae/labridae	5	20.0%
Lutjanidae	3	12.0%

Diodontidae	2	8.0%
Nemipteridae	2	8.0%
Balistidae	1	4.0%
Scombridae	1	4.0%
Serranidae	1	4.0%
Total	25	

Appendix 7

Buang Merabak Shark Teeth

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All teeth from species of the Whaler genus Carcharhinus. Table 1 lists the identifications for selected specimens.

Table 1: Buang Merabak shark tooth.

Spit/ No	**Jaw and approx. tooth position**	**Scientific and common name**	**Comments**
TP1 Spit 5 #01	Lower, left, row 3-6	*C. falciformis*, (Bibron, 1839) silky shark	Similar to *C. tilsoni,* and *C. plumbeus*, both of which have serrated margins to the base of the crown but *C. falciformis* has serrations only ~1/3 of way down.
TP1A Spit 9 #02	Upper, right, row 3-5	*C. falciformis,* (Bibron, 1839) silky shark	Very near to *C. albimarginatus* but that species has fine serrations on mesial margin of crown (cf. coarser in *C. falciformis*). From ~2-2.2 m shark
TP1A Spit 11 #03	Upper, left, row ~5	*C. falciformis,* (Bibron, 1839)	Much of root broken off.
TP1A Spit 11 # 04	Upper, left, row (?3) 4	*C. cautus* (Whitley, 1945) nervous shark, or ?*C.melanopterus* (Quoy & Gaimard, 1824) blacktip reef shark	*C. cautus* seems a better fit than *C. melanopterus* which appears to have a more marked concavity of mesial margin.
TP1A Spit 11 #05	Upper, left, row 1 or 2	*C. falciformis*, (Bibron, 1839)	From ~2.4 m shark
TP1A Spit 11 #06	Upper, right, row ~5	*C. longimanus* (Poey, 1861) oceanic whitetip shark (close to *C. obscurus* (Lesueur, 1818), dusky shark	Similar to *C. obscurus* UR row 1 but in that tooth position the angle of divergence of the root is more acute than in this specimen. Concavity of distal margin of this tooth is almost identical to that of *C. longimanus* row 5, so too is shape of lower tooth margin. From ~2.4 m shark
TP1B Spit 14 #07	Upper, right, row 6-8	*C. falciformis*, (Bibron, 1839) silky shark	From ~2.5 m shark
TP1A Spit 32 #08	Upper, ?, row ~1 or 2	*Carcharhinus* sp.	A bit like lower tooth of *C. longimanus* but in 32/08 specimen the mesial and distal margins are a little more concave, and the serrations more evenly finer along the length of the margins, *cf. C. longimanus*

In addition to those listed in table 1, TP1A had at least 6 shark teeth. They were from:

TP1A	Spit 6	1 tooth	
TP1A	Spit 7	1 tooth	
TP1A	Spit 32	1 tooth	
TP1B	Spit 34	2 teeth	
TP1B	Spit 35	1 tooth	#09

Galeocerdo aduncus.

The teeth from Spits 34 and 35 (#09) appears similar to Kemp (1991), Plate 2E. This specimen is labeled *Galeocerdo aduncus* anterior tooth of upper jaw, labial view (NMV P26770).

Of the species G. *aduncus*, Kemp (1991:517, 515) states:

"An extant cosmopolitan species of tiger shark *Galeocerdo aduncus* Ag., which occurs from the early Oligocene e.g. France (Priem 1906) through to the early Pliocene e.g. Australia (Pledge 1985) makes its first appearance in Australia in the early Miocene. It is found in the Morgan limestone of the Murray River cliffs, near Morgan, at Batesford, at a number of early Miocene localities in Western Victoria e.g. Hordern Vale, Fischers Point, near the Gellibrand River, and the Middle Miocene Muddy Creek Marl near Hamilton.

Teeth very similar to one genus of hammerhead, Sphyrna, and referred to as *Sphyrna* sp. 1 and *Sphyrna* sp. occur in the Cape Grim beds in Tasmania and the Batesford Limestone at Batesford respectively." (Kemp 1991:515)

"The cosmopolitan extinct tiger shark *G. aduncus* continues in Australia, in the Late Miocene and Early Pliocene at Beaumaris, Forsythes Bank at Grange Burn and in the Loxton Sands. It is known as late as the Pliocene in Japan (*fide* Cappetta 1987). A small number of teeth from the Loxton Sands, referred to as *cf. Sphyrna sp.* (Pledge 1985), and the first Australian record of *Sphyrna*, appears to be that genus." (Kemp 1991:517)

Miocene = 24 Ma to 5 Ma
Pliocene = 5 Ma to 1.8 Ma
Pleistocene = 1.8 Ma to 10,000.

The Buang Merabak spit 35 (#09) *G. aduncus* tooth is 25 mm in length and represents a fish of approximately 4 m in length (one of the spit 34 teeth is 30mm).

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Appendix 8

Class: Reptilia Identifications

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Introduction

New Ireland represents a good opportunity to explore the current lack of knowledge of Melanesian palaeoherpetology because the living fauna is a relatively simple one, consisting of approximately 50 species. This makes comparisons relatively easy, and is in contrast to the situation on mainland New Guinea where the living frog and lizard faunas are extremely speciose (Allison, 1982; Zweifel and Tyler, 1982). Recent archaeological excavations at Buang Merabak (ML) have resulted in the collection of the faunal material that is partially presented here. It has yielded a collection of well over a hundred specimens of reptile remains comprising mostly vertebrae and tooth-bearing bones. These are recognisable as belonging to four lizard taxa, four snakes and – frogs, all of which may have been potential food resources. Most are attributable to species still extant on New Ireland, but one is described as a new species of skink of unusually large size. Limited samples of reptile material are also available from two of the other sites, Panakiwuk and Matenkupkum, and these include important additional skeletal elements for some of the Buang Merabak taxa.

Family Scincidae Oppel, 1911
Genus *Eugongylus* Fitzinger, 1823
***Eugongylus esculentus* n. sp.**

Holotype: Left/right partial mandible, SAMA P#789, Buang Merabak, New Ireland, Papua New Guinea.

Paratypes: partial mandible, SAMA P#1761, dentaries, SAMA P#783, #785, #793. #817, #818, #823, #825, #880; partial dentaries, SAMA P#784, #787, #791, #813, #815, #816, #819, #822,

#824, maxillae, SAMA P#792, #820, #826; partial maxillae SAMA P#788, #790, #827, frontal SAMA P#1114, all from Buang Merabak.

Referred specimens: Parietal, SAMA P A6S/14, Panakiwuk; frontal, SAMA P A6S/14, Y2/7, A6S/3, Panakiwuk; MKK_G5, MKK_E6, Matenkupkum; partial braincase (basioccipital, otoccipitals and supraoccipital), SAMA P A5/15, Panakiwuk; maxilla SAMA P Z6S/12, Panakiwuk, MKK_J11, Matenkupkum; mandibles, MKK_L9, MKK_O3, Matenkupkum; pelvis, SAMA 25/2, 25/11c, A6S/16, Panakiwuk.

Diagnosis: A very large member of the *Eugongylus* Group (est. skull length 45 mm) with robust jaws and cheek teeth having broad, convex crowns. Paired frontoparietals. Other *Eugongylus* species have sharper-crowned teeth and more elongate *jaws (E. albofasciolatus*) and are markedly smaller in size (*E. rufescens* and *E. unilineatus*). Compared to other members of the *Eugongylus* Group in the Melanesian region, *E. esculentus* is approached in size by *Phoboscincus* (New Caledonia) and *Tachygia* (Tonga), but distinguished by paired rather than single frontoparietals and (*Phoboscincus* only) absence of recurved, fanglike tooth shape.

Comparisons

Of the living species of *Eugongylus* currently recognised, *E. albofasciolatus* is closest in size but *E. rufescens* is closest in proportions. The distinctive dentition *of E. esculentus*, with its robust, flattened crowns is in contrast to the relatively slender pointed teeth of *E. albofasciolatus*, and the latter species also has a more gracile, elongate jaw with more numerous teeth. *Eugongylus rufescens* has fewer, more robust teeth than *E. albofasciolatus* and has a shorter, relatively more robust jaw. In both respects it is more similar to *E. esculentus,* but the dentition is much less robust, and the crowns much less expanded than in *E esculentus*., and *E. rufescens* reaches little more than half its size. The third species, *E. unilineatus*, is still smaller again. We have also examined alcohol-preserved material of an as yet undescribed species of *Eugongylus* from Micronesia; this species is similar in size to *E. rufescens* but its proportions and external appearance are closer to *E. albofasciolatus*.

Family Agamidae

Genus *Hypsilurus*

cf. *Hypsilurus godefroyii*

Material: Dentaries from Buang Merabak
The only large agamid currently known from New Ireland is *Hypsilurus godefroyii*

Family Gekkonidae

Genus ?

Material: Dentary from Buang Merabak. Frontal and maxillae from Panakiwuk.
The only extant New Ireland geckos of a size consistent with the Buang Merabak specimens are *Gehyra oceanica* and *Gekko vittatus.*

Family Varanidae

Genus *Varanus*

Varanus indicus species-group

Material: Maxillae, dentaries, pterygoids, supraorbitals, vertebrae and limb bones from Buang Merabak.

Both *V. indicus* and *V. finschi,* sibling species with closely similar morphologies, are known to occur in the Bismarck Archipelago (Ziegler et al., 1999). The most likely candidate for the New Ireland samples is *V. indicus* itself, given the near-coastal nature of the cave sites and indeed of land surface of the entire island, but the comparative osteology of the two species has not yet been studied. Our comparative specimen is a sub-adult male *V. indicus*, and the Buang Merabak specimens were closely similar in morphology, although in many cases larger.

Discussion

Island lizards have, like other island faunal elements, evolved a number of distinctive forms that have rapidly succumbed to pressure from invading humans, either through direct exploitation for food or through habitat loss or predation due to human activities or human commensals (notably rats). In historic times, giant lizards on the Cape Verdes ((Greer, 1976), and the Canary Islands (Barahona et al., 2000)) have become extinct due to such anthropogenic disturbance, while subfossil and other remains show the demise of giants due to neolithic human arrival in other island ecosystems (Pregill and Dye, 1989; Bauer and Russell, 1986). The disappearance of *Eugongylus esculentus* from New Ireland was apparently not a rapid collapse, as has been the case on other islands, as its remains occur throughout most of the sediment column from the time of human arrival. The Panakiwuk specimens are from analytical units A, B and D spanning from >15,000 BP until between 1,600-640 BP. The Matenkupkum specimens are from layers within both the early and later units of occupation spanning from 35,000 BP until 10,000 BP. The Buang Merabak specimens were throughout the column from 35,000 BP until between 12,000-1,800 BP. Based on the Panakiwuk data and supported by the Buang Merabak data the evidence suggests that *Eugonglylus esculentus* was extant at least until the last 2-3,000 years BP. The present database is not large enough (too few specimens from too few sites) and the temporal framework is not fine enough (effectively 10,000 years at Buang Merabak), to make any informed remark about the cause of the extinction of *Eugongylus esculentes.*

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Appendix 9

Taxonomic and Stratigraphic Analysis of Archaeological Rodent Remains from Buang Merebak and Panakiwuk, New Ireland, and from Pamwak Rockshelter, Manus Island, Papua New Guinea: A Progress Report.

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Introduction

Murid rodents are reported from a number of cave excavations on New Ireland, including Balof Shelters (White et al. 1991), Panakiwuk (Marshall and Allen (1991), Matenkupkum (Gosden and Robertson (1991) and Buang Merabak (Leavesley 2004). To date, a total of only four murid species are recorded: *Melomys rufescens*, *Rattus praetor*, *Rattus exulans* and *Rattus mordax sanila*, the last of which was described by Flannery and White (1991) from a good series of archaeological specimens from late Pleistocene to mid-Holocene horizons in the Balof sites. Interestingly enough, there is no trace in these rich and extended archaeological sequences of two very distinctive murid species that are endemic today to New Britain, namely *Uromys neobrittanicus* and *Hydromys neobrittanicus*.

Rattus mordax sanila is not recorded as a living animal and Flannery and White (1991) promoted the view that it may have declined to extinction following the mid-Holocene introduction of *R. praetor*. Musser and Carleton (1993) elevated *R. mordax. sanila* to full species rank in their influential checklist, based primarily on its greater size than any population of *Rattus mordax*, including the distinctive subspecies *R. mordax fergussoniensis* from the D'Entrecasteaux and Trobriand Island groups.

Rattus praetor today occurs on both New Britain and New Ireland, and beyond, throughout the Solomon Islands (Taylor, Calaby and Van Deusen 1982). It is also found in the north coastal lowlands of New Guinea, but only west of the Sepik River mouth. *Rattus mordax* is confined to southeast part of Papua New Guinea, with a distinctive subspecies present on the adjacent islands groups, as noted above.

Flannery and White (1991: 104) reported that *R. mordax sanila* is present "from the basal, pre-human levels of Balof 1 and Balof 2 up to levels dating to between 3000 and 7000 bp, and *R. praetor* in levels above this". White et al. (1991) provide a more detailed tabulation for Balof 2 that shows *R. praetor* and *R. exulans* both restricted to Horizons I and II, while *Melomys rufescens* and *R. mordax sanila* occur to the base of the site. The latter taxon is absent from Horizon I.

Marshall and Allen (1991:78) reported much greater stratigraphic overlap between *R. mordax* and each of *R. praetor* and *R. exulans* in the Panakiwuk site. They claim that *Rattus praetor* "first appears in Panakiwuk in Stratigraphic Unit 11 (c. 13,000 bp) from which time on it is common in the site. *R. mordax* first appears in Stratigraphic Unit 14 (>c. 15,000 bp; essentially, the base of the sequence) and continues until Stratigraphic Unit 4 (c. 1,600 bp)" . *Rattus exulans* is also present down to Stratigraphic Unit 11. However, in view of the general view that this species is "a late Holocene human introduction into the Pacific", the authors conclude that "the one bone of this species in Analytical Unit C and the two further bones in Analytical Unit B are most parsimoniously considered to be derived from more recent levels". Despite the apparent evidence from Panakiwuk for long temporal overlap between *R. mordax sanila* and *R. praetor*, Marshall and Allen (1991) supported the view that *R. praetor* was introduced by human agency and contributed to the extinction of *R. mordax sanila.*

As a further development, Williams (1999) reported archaeological murid remains from the Pamwak site on Manus Island, to the north of Papua New Guinea. She identified four murid species, namely *Melomys rufescens, Rattus rattus, R. mordax* and *R. praetor*. *Rattus rattus* was identified from levels as old as 11,000 bp, and *R. praetor* from levels dating to 9,000 bp. *Rattus mordax* was confined to the upper levels of the site, when *R. praetor* was no longer present. Williams (1999) remarked on the anomalous nature of these findings. Only *Melomys rufescens, R. rattus* and *R. praetor* are recorded as living animals from Manus Island, although *Rattus exulans* is almost certainly present too.

The archaeological sequence from Buang Merabak provided another opportunity to examine the history of these taxa on New Ireland, and further to re-examine the issue of the taxonomic identity of *R. sanila* and its relationship to *R. mordax.*

Method

All murid specimens from Buang Merabak were examined, sometimes after immersion in weak acetic acid (vinegar) to remove obscuring carbonate encrustation. The major post-cranial elements (major limb bones, pelvic fragments) as well as cranial remains were examined. The murid samples from Panakiwuk and Pamwak was also re-examined simultaneously with the Buang Merabak analysis to facilitate consistency among the identifications.

Modern reference specimens of *R. exulans, R. mordax mordax, R. mordax fergussoniensis, R. praetor* (mainland and island populations), *R. rattus* and many other New Guinean and Asian species of Rattus were examined from the collections of the Australian Museum, Sydney, and the Australian National Wildlife Collection, CSIRO, Gungahlin.

Results

The preliminary results are listed below. A full account of the results will be presented in the near future, following resolution of some taxonomic issues. However, sufficient work has been completed to date to support the following conclusions:

Taxonomic conclusions

1. The Buang Merabak and Panakiwuk samples of *Rattus mordax sanila* both consist of mixed assemblages of two species, each of which is very distinct in dental morphology from each of typical *R. mordax, R. mordax fergussoniensis, R. praetor* and all other extant New Guinean and Asian Rattus species.
2. The two fossil taxa are most similar to each other in molar morphology but differ in molar size, general skeletal robusticity, incisor (upper and lower) depth and width, minor details of molar morphology. Essentially, one taxon has relatively broad, deep incisors and slightly larger molars, supported by a robust cranial morphology, while the second taxon has more gracile incisors and slightly smaller molars, set in an overall more slender cranium. The postcranial material is also clearly divisible into one group of

larger, more robust elements and another group that is smaller and more gracile. The differences between the two taxa are comparable to those observed between many sympatric sibling pairs within Rattus, such as between *R. verecundus* and *R. leucopus* in the lowlands of southern New Guinea. The differences in relative incisor size and overall skeletal robusticity suggests some dietary differentiation between the two taxa.

3. Because the holotype of *Rattus mordax sanila* has yet to be compared with the newly identified material, it is not possible at present to be certain which taxon will bear the name sanila. For the present, we have listed the larger taxon as *R. 'sanila'* and the smaller one as *Rattus* sp. 2.
4. The two fossil taxa share a suite of archaic dental characteristics that are otherwise observed (in variable combinations) in several montane New Guinean Rattus species (*R. richardsoni* and *R. omlichoides*), and a number of other locally endemic *Rattus* species primarily found on remote islands or in mountain forests across peninsular and island South East Asia (Aplin et al. 2003). These taxa are thought to represent relicts of an early phase of dispersal of the genus Rattus through the wider Indo-Pacific region.

Buang Merabak sequence

1. Both endemic taxa are represented in reasonable numbers throughout the sequence, although *R. 'sanila'* appears to be slightly more numerous overall, and perhaps especially so in the upper levels of the site where *Rattus* sp. 2 is poorly represented, especially among the postcranial remains.
2. *Rattus praetor* is not represented by definite tooth-bearing elements in the Buang Merabak deposit. It is possible that a specimen identified as *R. sanila* or *Rattus* sp. 2 from Spit 5 in TP1B (a burnt right maxilla with a heavily worn M^{2-3} is actually referrable to *R. praetor*, but the relatively large size of the remaining teeth suggests otherwise. It is also possible that some of the post-cranial material identified as *Rattus* sp. 2 actually belongs to *R. praetor*. However, if this is the case, then the absence of any associated dental remains is difficult to accept.
3. *Rattus exulans* is represented by one post-cranial element in spit 11 of TP1A and is thought to have come from Unit 1 (Leavesley and Allen 1998) dated to 3500 bp to 1800 bp. We are reasonably confident about the allocation, but obviously a post-cranial determination it is less conclusive than one based on a tooth-bearing element.
4. *Melomys rufescens* is present throughout.

5. The Buang Merabak sequence clearly supports the notion that *R. praetor* and *R. exulans* are not part of the original mammal fauna of New Ireland but were introduced during comparatively recent prehistoric times.

Panakiwuk sequence

1. *Rattus praetor* is represented by at least 27 tooth-bearing elements. These are clearly distinguishable on both tooth size and morphology from *Rattus* sp. 2.
2. Of the 17 specimens of *Rattus praetor* that come from the main excavation area (Squares A5, Z5, A6S, Z6S), 11 come from Analytical Unit A (with dates of < 1700 bp), 5 come from Analytical Unit B (dates range from 6,000-10,000 bp), and one from Analytical Unit C (one date c. 13,000 bp). This distribution does not follow the overall distribution of bone, the bulk of which actually comes from Analytical Unit B.
3. All but two of specimens of *Rattus exulans* come from Analytical Unit A. As reported by Marshall and Allen (1991), the lowest tooth-bearing element is from Square Z5 spit 15, which is allocated to their Stratigraphic Unit 8, midway into Analytical Unit B. The lowest post-cranial element of this species comes from Stratigraphic Unit 6 in Square Z5 (spit 10), near the top of Analytical Unit B.
4. *Rattus 'sanila'* is found in all Analytical Units including the 'pre-human' Analytical Unit D. Of the 21 tooth-bearing elements, only one comes from Analytical Unit A.
5. *Rattus* sp. 2 is found in all Analytical Units including the 'pre-human' Analytical Unit D. Of the 20 tooth-bearing elements, four come from Analytical Unit A. Two of 14 specimens identified as either *Rattus 'sanila'* or *Rattus* sp. 2 come from Analytical Unit A.
6. The Panakiwuk sequence further supports the notion that *R. praetor* and *R. exulans* are human introductions to New Ireland, as both of these taxa are absent from the older horizons of this site. At face value, the evidence of Panakiwuk appears to favour two interpretations:
    a. an early introduction of *R. praetor* (perhaps in the interval 7,000-10,000 bp) and;
    b. a gradual decline of the endemic species, as indicated by the broad stratigraphic overlap of *R. praetor* with both *R. sanila* and *Rattus* sp. 2.
7. However, the absence of *R. praetor* from similar aged deposits in Buang Merabak urge caution in accepting either conclusion. Rather, the contrasting faunal sequences of the two sites would appear to favour the notion that the Panakiwuk faunal sequence this

somewhat compromised by local stratigraphic mixing between Analytical Units A and B. Marshall and Allen (1991: 78) admitted this possibility in their interpretation of the occasional specimens of *R. exulans* from positions low in the sequence.

Pamwak murids

Less time has been spent on the Pamwak collection. However, KA has done enough to offer the following remarks:

8. The great bulk of the material is referrable to two *Rattus* species, one larger and one smaller form. The larger taxon is about the size of *R. leucopus* from southern New Guinea. The smaller one is about the size of *R. praetor*.
9. Both taxa are similar in dental morphology to members of what is sometimes called the '*Stenomys*' assemblage among New Guinean Rattus (includes species such as *R. verecundus, R. leucopus, R. praetor* and R. *niobe*).
10. Despite this general similarity, neither of these taxa appears to be particularly close to *R. praetor* and KA is inclined to the view that both represent endemic taxa.
11. A few badly preserved specimens from the uppermost levels of the site are probably referrable to *R. praetor*.
12. No specimens are referrable to *R. mordax* or *R. rattus*, as claimed by Williams (1999). These taxa are individually, distinctly different in dental morphology from members of the '*Stenomys*' group.

Discussion

This new study of the New Ireland and Manus Island archaeological rodent remains has revealed a more complex story than previously understood. Not one but two endemic species of Rattus are present in the archaeological faunas, and neither is related specifically to *Rattus mordax*. One of these taxa is *Rattus sanila*, the other is currently unnamed. This finding, together with the radical reinterpretation of the Pamwak rodent fauna, serves to highlight some the difficulties involved in the identification of fragmentary murid remains, especially those of the genus Rattus.

The new study also further demonstrates the value of studying multiple archaeological sequences from one region, and emphasises the need for caution when only one or a small number of sequences are available for analysis. Reanalysis of the remains from the Balof sites and from

Matenkupkum is now required to further clarify the history of rodent introductions and extinctions on New Ireland.

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Buang Merabak and Panakiwuk Rodents (identification by KA).

Site	TP/SQ	Spit	Taxon	Element	Symmetry	Teeth	Alveolae	Wear	burning	notes
BM	A	7	Rattus 'sanila'	maxilla	right	M1-3		moderate	burnt	
BM	A	7	Rattus 'sanila' or sp. 2	maxilla	right	M1-3		slight	burnt	
BM	A	7	Rattus 'sanila' or sp. 2	dentary	left		Incisor + M1-3		burnt	
BM	A	8	Rattus sp. 2	dentary	right	M1-3		moderate	burnt	
BM	A	10	Melomys rufescens	dentary	right		M1-3		unburnt	
BM	A	10	Rattus 'sanila' or sp. 2	maxilla	left				unburnt	
BM	A	11	Melomys rufescens	dentary	left	M1-2			unburnt	
BM	A	11	Rattus 'sanila' or sp. 2	dentary	left		Incisor + M1-3		burnt	
BM	A	12	Rattus sp. 2	dentary	left	Incisor + M1-3		moderate	burnt	
BM	A	13	Melomys rufescens	dentary	left	M2			unburnt	
BM	A	14	Melomys rufescens	dentary	left	Incisor + M1-3			unburnt	
BM	A	14	Melomys rufescens	dentary	right	M1-3			unburnt	
BM	A	15	Rattus 'sanila' or sp. 2	dentary	right		Incisor + M1-3		unburnt	
BM	A	16	Melomys rufescens	dentary	right	Incisor + M1-3			unburnt	
BM	A	17	Melomys rufescens	dentary	left	M1-2			unburnt	
BM	A	17	Melomys rufescens	dentary	left	Incisor + M1-3			unburnt	
BM	A	17	Melomys rufescens	dentary	left		M1-3		unburnt	
BM	A	17	Rattus sp. 2	dentary	right	M1-2		slight	unburnt	
BM	A	17	Rattus sp. 2	dentary	left	M1-2		moderate	unburnt	
BM	A	17	Rattus sp. 2	dentary	left	M1-2		moderate	burnt	
BM	A	18	Melomys rufescens	dentary	right		M1-3		unburnt	
BM	A	18	Rattus 'sanila' or sp. 2	dentary	left		Incisor + M1-3		burnt	
BM	A	19	Rattus sp. 2	dentary	left	Incisor + M1-2		moderate	unburnt	
BM	A	20	Melomys rufescens	dentary	right	Incisor + M1-3			unburnt	
BM	A	20	Rattus 'sanila' or sp. 2	maxilla	left	M3	M1-2		burnt	
BM	A	22	Melomys rufescens	dentary	left	Incisor + M1-3			unburnt	
BM	A	23	Melomys rufescens	dentary	right	M1-3			unburnt	
BM	A	23	Melomys rufescens	dentary	right	Incisor + M1-3			unburnt	
BM	A	24	Melomys rufescens	dentary	left	Incisor + M1-3			unburnt	
BM	A	24	Melomys rufescens	dentary	right	Incisor + M1-3			unburnt	
BM	A	24	Rattus 'sanila'	dentary	right	Incisor + M1-2		moderate	unburnt	
BM	A	25	Melomys rufescens	dentary	left	Incisor			unburnt	
BM	A	26	Melomys rufescens	dentary	right	M1-2			unburnt	
BM	A	27	Melomys rufescens	dentary	left	M1-3			unburnt	
BM	A	27	Rattus 'sanila'	dentary	left	Incisor + M1		slight	unburnt	
BM	A	29	Rattus 'sanila' or sp. 2	dentary	right		M1-3		unburnt	
BM	A	29	Rattus 'sanila' or sp. 2	dentary	right		Incisor + M1-3		burnt	
BM	A	29	Rattus 'sanila' or sp. 2	dentary	left		Incisor + M1-3		unburnt	
BM	A	30	Rattus 'sanila' or sp. 2	dentary	right		M1-3		burnt	
BM	A	30	Rattus 'sanila' or sp. 2	dentary	right		Incisor + M1-3		unburnt	

BM	A	31	Rattus 'sanila' or sp. 2	dentary	right		Incisor + M1-3		burnt
BM	A	32	Melomys rufescens	dentary	left	M1-3			unburnt
BM	A	32	Rattus sp. 2	dentary	left	M1-3		heavy	unburnt
BM	A	33	Melomys rufescens	dentary	left	M1-2			unburnt
BM	A	33	Melomys rufescens	dentary	right		M1-3		unburnt
BM	A	33	Rattus 'sanila'	dentary	right	M2		heavy	unburnt
BM	A	34	Rattus 'sanila' or sp. 2	dentary	left		M1		unburnt
BM	B	5	Rattus 'sanila' or sp. 2	maxilla	right	M2-3	M1		burnt
BM	B	8	Rattus sp. 2	dentary	left	Incisor	M1-3		unburnt
BM	B	12	Melomys rufescens	dentary	right	Incisor + M1-2			unburnt
BM	B	17	Rattus sp. 2	dentary	left	Incisor + M1-2		moderate	unburnt
BM	B	19	Rattus 'sanila'	dentary	left	M1-3		moderate	burnt
BM	B	19	Rattus sp. 2	dentary	left	M1-3		slight	unburnt
BM	B	20	Melomys rufescens	dentary	right	M1-2			unburnt
BM	B	20	Melomys rufescens	dentary	right	M1-2			unburnt
BM	B	20	Rattus 'sanila' or sp. 2	dentary	right		Incisor + M1-3		unburnt
BM	B	20	Rattus sp. 2	dentary	left	M1-3		moderate	unburnt
BM	B	21	Melomys rufescens	dentary	left		M1-3		unburnt
BM	B	21	Rattus 'sanila' or sp. 2	dentary	left		Incisor + M1-3		unburnt
BM	B	22	Rattus 'sanila'	dentary	right	M1-3		slight	unburnt
BM	B	22	Rattus sp. 2	dentary	left	Incisor + M1-3		slight	unburnt
BM	B	24	Rattus sp. 2	dentary	left	Incisor + M1-3		moderate	unburnt
BM	B	25	Melomys rufescens	dentary	right	Incisor + M1-3			unburnt
BM	B	27	Melomys rufescens	dentary	left	Incisor + M1-3			unburnt
BM	B	28	Rattus sp. 2	maxilla	right	M1-3		slight	unburnt
BM	B	28	Rattus sp. 2	dentary	right	M1-2		slight	unburnt
BM	B	32	Rattus sp. 2	dentary	left	M1-3		moderate	unburnt
BM	B	34	Rattus 'sanila'	dentary	left	M1-3		heavy	unburnt
BM	B	34	Rattus 'sanila' or sp. 2	dentary	left		Incisor + M1-3		unburnt
BM	B	35	Rattus 'sanila'	dentary	left	M1-2		heavy	unburnt
BM	B	35	Rattus sp. 2	dentary	left	M1		moderate	unburnt
BM	B	38	Rattus 'sanila'	dentary	left	M1-2		moderate	unburnt
BM	B	40	Rattus 'sanila' or sp. 2	dentary	right		Incisor + M1-3		burnt
PWK	A5	4	Rattus sp. 2	dentary	right	Incisor + M1-3		moderate	unburnt
PWK	A5	5	Rattus exulans	dentary	right	Incisor + M1-2		moderate	unburnt
PWK	A5	6	Rattus praetor	dentary	left	M1-3		heavy	burnt
PWK	A5	6	Rattus sp. 2	dentary	right	Incisor + M1-2		moderate	unburnt
PWK	A5	6	Rattus sp. 2	dentary	right	Incisor + M1-2		moderate	unburnt
PWK	A5	7	Rattus praetor	dentary	left	M1		moderate	unburnt
PWK	A5	8	Rattus praetor	dentary	left	M1-3		heavy	unburnt
PWK	A5	8	Rattus 'sanila'	maxilla	left	M1-3		moderate	unburnt
PWK	A5	10	Rattus 'sanila' or sp. 2	dentary	right		M1-3		unburnt
PWK	A5	10	Rattus sp. 2	dentary	left	M1-2		slight	unburnt
PWK	A5	15	Rattus praetor	dentary	left	Incisor + M1-2		moderate	unburnt
PWK	A5	4a	Rattus exulans	dentary	right		M1-3		unburnt
PWK	a5	4	Rattus sp. 2	dentary	right	M1	M1-3		unburnt

PWK	A6S	5	Rattus exulans	dentary	left	Incisor + M1		moderate	unburnt
PWK	A6S	5	Rattus exulans	dentary	right		Incisor + M1-3		unburnt
PWK	A6S	5	Rattus praetor	maxilla	right	M1-2		moderate	unburnt
PWK	A6S	6	Rattus exulans	maxilla	left		M1-3		unburnt
PWK	A6S	12	Rattus 'sanila' or sp. 2	dentary	left		M1-3		unburnt
PWK	A6S	12	Rattus 'sanila' or sp. 2	dentary	right		M1-3		unburnt
PWK	A6S	12	Rattus sp. 2	maxilla	right	M1-3		moderate	unburnt
PWK	A6S	12	Rattus sp. 2	dentary	left	Incisor + M1-2		moderate	unburnt
PWK	A6S	13	Rattus praetor	maxilla	right		M1-3		unburnt
PWK	A6S	13	Rattus 'sanila'	maxilla	right	M1		heavy	unburnt
PWK	A6S	13	Rattus 'sanila'	maxilla	right	M1-3		moderate	unburnt
PWK	A6S	13	Rattus 'sanila'	maxilla	right		M1-3		unburnt
PWK	A6S	13	Rattus 'sanila' or sp. 2	maxilla	left		M1-3		burnt
PWK	A6S	13	Rattus 'sanila' or sp. 2	maxilla	right		M1-3		unburnt
PWK	A6S	13	Rattus 'sanila' or sp. 2	maxilla	left		M1-3		unburnt
PWK	A6S	13	Rattus sp. 2	dentary	right	Incisor + M1-2		moderate	unburnt
PWK	A6S	13	Rattus sp. 2	dentary	left	Incisor + M1-3		moderate	unburnt
PWK	A6S	13	Rattus sp. 2	dentary	right	Incisor + M1-3		moderate	unburnt
PWK	A6S	15	Rattus 'sanila'	dentary	left	M1-2		moderate	unburnt
PWK	A6S	15	Rattus 'sanila' or sp. 2	maxilla	left		M1-3		unburnt
PWK	A6S	15	Rattus 'sanila' or sp. 2	maxilla	right	M3	M1-2	heavy	unburnt
PWK	A6S	15	Rattus sp. 2	dentary	left	Incisor + M2-3		heavy	unburnt
PWK	A6S	15	Rattus sp. 2	dentary	right		Incisor + M1-3		unburnt
PWK	A6S	16	Rattus 'sanila'	dentary	right	M1-2		moderate	unburnt
PWK	A6S	16	Rattus 'sanila' or sp. 2	dentary	right	M2		moderate	unburnt
PWK	A6S	18	Rattus 'sanila'	maxilla	left	M1		heavy	unburnt
PWK	Y2	M3	Rattus exulans	dentary	right		M1-3		unburnt
PWK	Y2	M3	Rattus exulans	dentary	left		M1-3		unburnt
PWK	Y2	M3	Rattus praetor	dentary	left		M1-3		unburnt
PWK	Y2	M3	Rattus praetor	dentary	left	Incisor	M1-3		unburnt
PWK	Y2	M3	Rattus praetor	maxilla	right	M1		heavy	unburnt
PWK	Y2	M3	Rattus praetor	maxilla	left	M1		heavy	unburnt
PWK	Y2	M3	Rattus praetor	maxilla	left		M1		unburnt
PWK	Y2	4	Rattus exulans	dentary	right		M1-3		unburnt
PWK	Y2	4	Rattus exulans	dentary	left		M1-3		unburnt
PWK	Y2	4	Rattus praetor	maxilla	left		M1-2		unburnt
PWK	Y2	4	Rattus praetor	maxilla	right		M1		unburnt
PWK	Y2	4	Rattus praetor	maxilla	left		M1		unburnt
PWK	Y2	4	Rattus praetor	dentary	right		M1		unburnt
PWK	Y2	4	Rattus praetor	dentary	left		M1-3		unburnt
PWK	Z5	5	Rattus praetor	dentary	right	Incisor	M1-3		unburnt
PWK	Z5	6	Rattus exulans	dentary	right	M1		moderate	unburnt
PWK	Z5	6	Rattus praetor	dentary	right	Incisor	M1-3		unburnt
PWK	Z5	9	Rattus praetor	dentary	right		M1-3		unburnt
PWK	Z5	9	Rattus 'sanila'	maxilla	right	M1-3		moderate	unburnt
PWK	Z5	11	Rattus praetor	dentary	right	M1		moderate	unburnt
PWK	Z5	13	Rattus praetor	dentary	right	M1-2		moderate	unburnt

PWK	Z5	19	Rattus 'sanila'	maxilla	left		M1-3		unburnt	Pair with following
PWK	Z5	19	Rattus 'sanila'	maxilla	right		M1-3		unburnt	pair with previous
PWK	Z5	19	Rattus 'sanila'	dentary	left		M1-3		unburnt	
PWK	Z5	19	Rattus 'sanila'	dentary	right	M1	M1-3		unburnt	
PWK	Z5	20	Rattus 'sanila'	maxilla	left		M1-3		unburnt	
PWK	Z5	20	Rattus 'sanila' or sp. 2	maxilla	left		M1-3		unburnt	
PWK	Z5	28	Rattus sp. 2	dentary	left	M1-2		moderate	unburnt	
PWK	Z5	31	Rattus sp. 2	maxilla	left	M1-3		heavy	unburnt	
PWK	Z6S	M1	Rattus praetor	dentary	right	Incisor + M1-2		heavy	unburnt	
PWK	Z6S	M1	Rattus 'sanila' or sp. 2	dentary	right	M1-2		heavy	burnt	
PWK	Z6S	M2	Rattus praetor	maxilla	left	M1-3		slight	unburnt	
PWK	Z6S	M2	Rattus 'sanila' or sp. 2	dentary	right	M1-2		heavy	unburnt	
PWK	Z6S	5	Rattus exulans	dentary	left		M1-3		unburnt	
PWK	Z6S	5	Rattus praetor	maxilla	right	M1		heavy	unburnt	
PWK	Z6S	5	Rattus praetor	maxilla	left		M1		unburnt	
PWK	Z6S	5	Rattus 'sanila' or sp. 2	dentary	right	M1-2		moderate	unburnt	
PWK	Z6S	7	Rattus praetor	dentary	left	M1,M3		heavy	unburnt	
PWK	Z6S	8	Rattus sp. 2	dentary	right	Incisor + M1-3		moderate	unburnt	
PWK	Z6S	9	Rattus 'sanila'	dentary	right	M1-3		heavy	unburnt	
PWK	Z6S	10	Rattus 'sanila'	dentary	left	M1-3		moderate	unburnt	
PWK	Z6S	10	Rattus sp. 2	maxilla	left	M1		moderate	unburnt	
PWK	Z6S	11	Rattus 'sanila'	maxilla	right		M1-3		unburnt	
PWK	Z6S	11	Rattus 'sanila'	dentary	left	M1-2		moderate	unburnt	
PWK	Z6S	11	Rattus 'sanila'	dentary	right	M1		moderate	unburnt	
PWK	Z6S	11	Rattus 'sanila'	dentary	right		M1-3		unburnt	
PWK	Z6S	11	Rattus sp. 2	maxilla	right	M1-3		slight	unburnt	
PWK	Z6S	12	Rattus praetor	maxilla	left	M2	M1		unburnt	
PWK	Z6S	12	Rattus 'sanila' or sp. 2	maxilla	left	M2		moderate	unburnt	
PWK	Z6S	12	Rattus sp. 2	dentary	left	M1-2		slight	unburnt	
PWK	Z6S	12	Rattus sp. 2	dentary	left	M1		moderate	unburnt	
PWK	Z6S	12	Rattus sp. 2	dentary	left	Incisor + M1-3		moderate	unburnt	
PWK	Z6S	13	Rattus 'sanila'	dentary	left	M1-2		moderate	unburnt	
PWK	Z6S	14	Rattus 'sanila'	dentary	right	M1-3		moderate	unburnt	

Appendix 10

Buang Merabak TP1A Stone Artefacts

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This appendix presents and describes the stone assemblage from Buang Merabak TP1A. The assemblage is described in terms of whole and broken flakes and angular fragments. Also length, width and thickness measurements were presented for each stone specimen. This study provides a preliminary overview of the assemblage in order to elucidate some of its general characteristics.

Method

Each specimen was designated to one of three types; whole flake, broken flake and angular fragment. The type was assigned on the basis of the presence of platform, bulb (present or detached) and termination. The length was recorded as percussion length and width and thickness were measured at right angles to the mid-length. Obsidian was not included in the analysis. The weight was measured on an electronic balance in the School of Archaeology and Anthropology at The Australian National University.

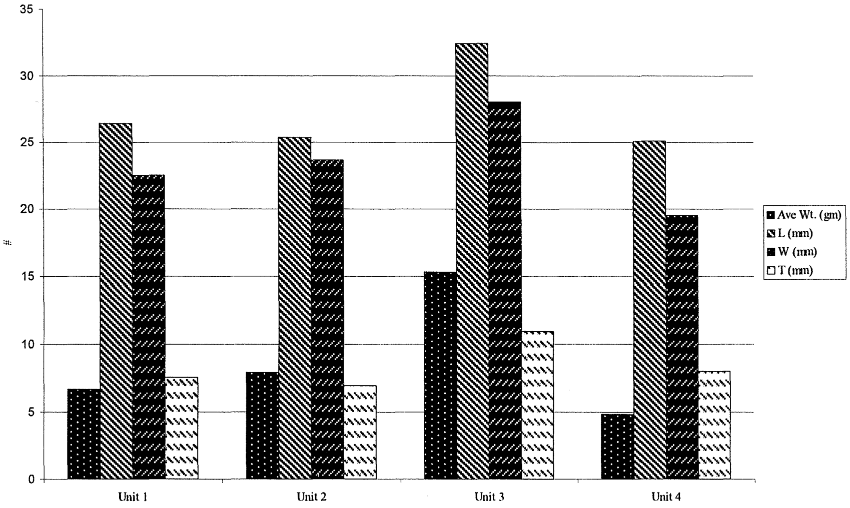

Figure 1: Average weight, length, width and thickness per unit.

Discussion

The stone assemblage contained 147 specimens at an average weight of 7.83 gms per specimen. Four artefacts reflected retouch. Table 1 and figure 1 indicate that all four Units contained stone artefacts or angular fragments. The average weight per specimen in Units 1 and 2 were similar to the assemblage average while the Unit 3 average is almost twice the assemblage average and Unit 4 is half the assemblage average.

Figure 2 indicates that the NAS and weight of specimens increases over time. Unit 4 contains the least specimens per 1000 years and Unit 1 contains the greatest. Units 3 and 2 contain a similar number and weight of specimens while Unit 1 contains more than twice as many specimens than any other Unit. The relative quantities of stone specimens between Unite 3 and 2 were similar the accumulation of the bone as indicated in Table 14 (Leavesley 2004).

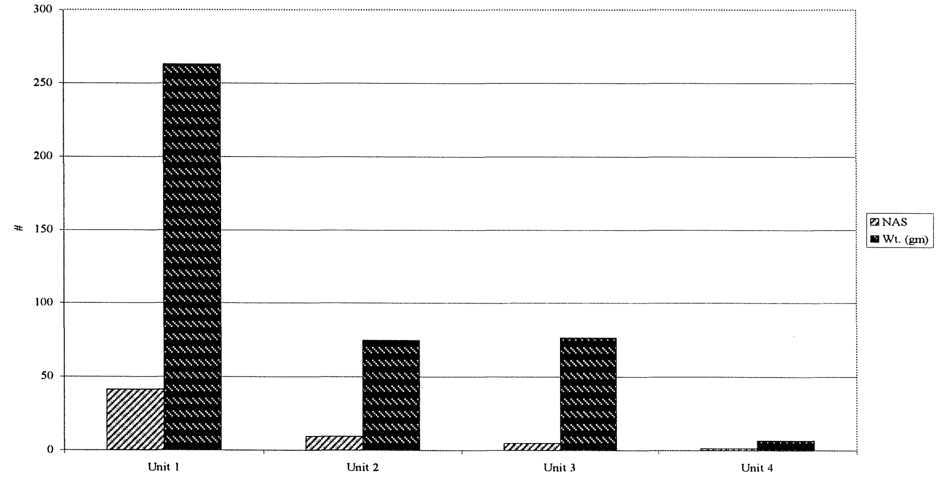

Figure 2: The NAS and weight (gm) per Unit per 1000 years.

Data

The data was recorded by Adrian Henham and describes artefacts and angular fragments from Buang Merabak TP1A only.

Table 1: Results of artefact analysis. Id= identification number; L=length; W=width and T= thickness (mm). Within the ‘Type category BF= broken flake; WF=whole flake and AF= angular fragment.

Id	Spit	Wt. (g)	L (mm)	W (mm)	T (mm)	Type	Comment
1	3	5.1	29.4	25.1	7.5	BF	
2	3	3.6	28.2	18.7	4.8	BF	
3	3	0.7	19.2	10.3	3.6	WF	
4	3	13.2	38.5	25.0	9.1	AF	
5	3	6.0	24.0	27.3	10.3	AF	
6	4	50.0	46.4	39.5	26.1	Core	
7	4	7.9	36.7	26.7	7.6	Retouch	
8	4	4.5	27.6	22.2	7.3	WF	Possible usewear
9	5	8.1	29.7	31.0	7.9	WF	
10	5	4.6	33.0	31.1	6.3	WF	
11	6	2.4	21.1	24.5	5.0	WF	
12	6	5.2	31.7	23.2	9.2	WF	
13	6	2.8	17.6	31.3	4.3	BF	
14	6	3.2	26.8	30.0	4.1	BF	
15	6	9.6	30.0	39.5	6.2	AF	
16	6	6.2	30.7	25.7	7.5	AF	
17	6	7.5	24.9	28.0	9.6	AF	
18	7	30.6	39.6	55.5	14.0	Retouch	Platform Prep. Possible Usewear
19	7	15.7	45.6	19.9	14.1	Retouch	
20	7	1.3	18.3	13.8	5.0	WF	Platform Prep.
21	7	5.8	37.6	20.0	8.3	WF	
22	7	0.7	13.5	13.7	4.2	BF	
23	7	13.3	48.9	28.9	11.1	WF	Platform Prep.
24	7	4.7	19.4	28.9	9.6	BF	Possible usewear
25	7	2.0	15.6	29.4	5.1	BF	
26	7	12.0	41.3	24.5	11.6	WF	
27	7	3.5	20.1	28.9	4.3	BF	
28	7	7.9	21.0	40.0	10.8	WF	Possible usewear
29	7	3.2	30.8	17.8	4.2	WF	
30	7	3.0	21.7	21.9	8.5	BF	
31	7	1.0	18.3	15.2	3.8	WF	
32	7	1.6	18.5	21.4	4.7	BF	
33	7	1.2	17.4	17.1	4.1	WF	
34	7	1.4	15.3	14.9	6.9	WF	
35	7	0.2	9.3	9.8	3.8	BF	
36	7	2.1	20.1	21.1	7.8	BF	
37	7	0.8	14.9	19.0	2.8	WF	
38	7	67.6	58.2	44.8	22.4	AF	
39	7	1.3	21.4	13.3	6.3	AF	
40	7	1.7	21.4	13.9	4.8	AF	
41	7	2.5	21.6	23.0	6.6	AF	
42	7	2.2	22.4	12.1	7.5	AF	
43	7	2.8	27.2	17.2	6.2	AF	
44	7	1.9	31.6	13.8	7.0	AF	
45	7	4.0	25.8	20.1	8.4	AF	
46	7	3.5	26.3	13.6	9.0	AF	
47	7	1.5	23.8	13.7	5.0	AF	
48	7	3.0	26.5	17.6	6.5	AF	
49	8	9.9	36.2	36.7	8.0	BF	

50	8	3.0	26.4	15.5	7.5	BF	
51	8	13.5	41.0	31.7	7.4	BF	
52	8	6.8	29.2	27.3	7.9	WF	
53	8	1.1	20.4	18.6	4.4	BF	
54	8	1.7	28.1	20.6	5.2	WF	
55	8	1.4	16.1	22.1	4.2	WF	
56	8	0.6	10.1	20.6	3.1	BF	
57	8	1.0	18.0	14.2	2.8	BF	
58	8	1.0	19.7	10.2	5.2	WF	
59	8	2.3	17.5	22.7	5.5	WF	
60	8	1.4	20.1	22.6	3.0	WF	
61	8	1.3	25.1	16.9	3.5	AF	
62	8	33.9	55.2	34.9	18.7	AF	
63	8	6.1	24.0	26.4	9.4	AF	
64	8	0.7	29.2	8.9	3.3	AF	
65	8	5.5	31.2	20.7	12.3	AF	
66	8	2.7	24.2	10.6	10.2	AF	
67	8	1.5	17.8	12.6	8.2	AF	
68	8	1.2	16.9	10.8	4.3	AF	
69	8	1.6	17.1	12.2	5.9	AF	
70	9	6.0	30.6	24.9	7.0	WF	
71	9	11.3	37.4	24.9	10.3	Retouch	
72	9	15.5	43.9	45.0	10.1	WF	
73	9	4.7	29.2	22.9	7.6	BF	
74	9	1.2	14.2	12.8	6.1	WF	
75	9	7.9	35.6	17.6	12.3	Core	Pebble with 1 flake out of it
76	9	0.4	8.6	13.9	1.9	BF	
77	9	1.1	18.6	18.2	3.1	WF	
78	9	1.6	18.8	20.7	5.3	WF	
79	9	5.7	25.2	26.1	15.2	BF	Connected to Calcified Shell
80	9	0.7	10.9	15.3	3.9	BF	
81	9	0.6	7.8	17.3	5.3	BF	
82	9	0.2	12.5	11.6	2.8	AF	
83	9	0.3	16.1	7.4	3.9	AF	
84	10	5.9	33.1	34.1	5.4	WF	
85	10	17.8	46.9	39.9	8.8	BF	
86	10	24.6	52.5	42.3	13.1	BF	
87	10	2.6	23.3	24.3	4.5	WF	
88	10	0.6	15.2	15.6	3.2	WF	
89	10	0.7	11.9	14.9	3.3	WF	
90	10	1.2	14.5	17.2	4.4	WF	
91	10	0.3	10.7	10.1	2.1	BF	
92	10	0.2	12.1	6.3	2.8	BF	
93	10	0.3	15.4	9.6	2.0	AF	
94	10	1.9	22.7	14.7	7.8	AF	
95	11	6.9	21.5	30.8	8.7	BC	
96	11	5.1	27.8	23.7	7.7	WF	
97	11	8.2	37.5	25.2	9.2	WF	
98	11	6.9	39.1	25.8	6.4	AF	
99	11	1.9	17.3	14.7	5.2	AF	
100	11	1.5	18.4	19.6	4.0	AF	
101	11N	0.3	8.7	16.5	2.5	BF	
102	11N	1.9	14.5	23.3	5.6	BF	

103	11N	0.9	13.9	10.6	4.8	AF	
104	12	32.5	55.6	44.6	14.6	BF	
105	12	12.4	30.3	46.4	10.2	BF	
106	12	5.2	28.4	22.1	7.5	BC	
107	12	1.9	23.3	11.8	7.8	Retouch	
108	12	6.5	42.6	19.4	4.8	AF	
109	12	4.4	22.3	16.7	9.7	AF	
110	14	5.3	33.8	17.1	8.3	WF	
111	15	75.6	55.7	68.1	15.3	WF	
112	16	4.0	22.3	28.6	8.4	WF	
113	17	64.6	47.4	65.4	13.7	WF	Use Wear
114	17	5.3	20.4	39.6	7.8	BF	
115	17	0.3	11.7	12.8	2.6	BF	
116	17	7.2	32.0	21.4	8.8	AF	
117	18	3.5	23.6	20.4	7.3	BF	
118	18	1.4	18.4	17.2	4.3	BF	
119	19	11.5	34.3	26.3	12.5	BF	
120	19	1.8	30.6	12.6	4.6	BF	
121	20	45.9	47.2	41.2	16.8	Retouch	Use Wear
122	20	1.5	24.3	19.2	3.8	BF	
123	20	5.8	31.3	22.8	7.3	BF	
124	20	0.5	16.6	11.5	3.4	WF	
125	22	27.3	42.8	29.4	18.9	WF	Platform Prep.
126	22	22.8	36.9	34.6	16.7	WF	
127	22	10.9	41.6	27.7	10.4	WF	
128	22	13.1	50.4	17.8	12.2	AF	
129	23	26.9	31.5	40.4	19.9	BF	
130	23	3.0	16.0	23.3	8.8	BF	
131	24	53.1	40.6	75.9	17.4	BC	
132	29	2.2	21.9	19.3	6.3	AF	
133	30	19.0	51.1	30.9	13.0	WF	
134	30	5.8	26.1	28.5	7.0	Retouch	Platform Prep.
135	30	7.1	25.1	24.7	8.9	BF	
136	30	7.0	42.8	14.4	9.4	AF	
137	30	7.2	23.1	20.8	12.8	AF	
138	31	2.8	24.1	22.6	6.5	BF	
139	32	2.7	10.2	8.1	5.2	BF	
140	32	4.2	26.4	16.2	6.1	BF	
141	32	6.4	34.0	20.0	8.9	WF	Platform Prep. Possible Usewear
142	32	12.9	31.2	37.3	9.3	AF	
143	33	1.3	18.3	23.2	7.9	BF	
144	33	0.9	19.9	15.0	6.7	BF	
145	33	1.1	14.1	17.2	13.1	BF	
146	33	0.3	22.4	9.0	5.2	BF	
147	34	1.2	23.9	11.6	7.0	WF	
148	34	0.3	11.9	12.9	2.8	WF	
149	S4W	23.8	36.3	36.6	17.8	BF	

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Appendix 11

Obsidian and Chert Geochemical Analysis

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Introduction

PIXE and PIGME analyses were carried out at the Australian Nuclear and Science Technology Organisation (ANSTO) laboratory in Lucus Heights in order to determine the elemental compositions of obsidian and chert artefacts from Buang Merabak, New Ireland. Comparable analyses were also undertaken from artefacts from Atkuranga and Valtakuikui sites in New Hanover and chert river pebbles from the Woi River, New Hanover.

1. Analytical techniques

1.1 Particle Induced X-ray Emission (PIXE)

PIXE was used to identify and quantify individual elements ranging from Al to U in the obsidian and chert artefacts. Samples were analysed in their original state at areas representative of the entire fragment. The artefacts were not damaged during this process.

The artefacts and rock fragments were irradiated by 2-3MeV protons produced by 3Van de Graaff and 10 MV tandem accelerators. X-ray detection was done by energy dispersive semiconductor detectors. The elemental composition were calculated by DOIBA with an oxide/iteration applied for Chert samples. The results are presented in Tables 1 and 2.

1.2 Particle Induced Gamma Ray Emission (PIGME)

PIGME is used to identify and quantify elements with low Z activities (light elements in the periodic table) including F and Na. The artefacts and rock fragments were analysed using large volume Ge detectors that calibrated emitted gamma rays produced by nuclear reaction of the sample following irradiation.

The results are presented in tables 1 and 2.

2.0 Sourcing Artefactual Materials

2.1 Obsidian

Obsidian is a volcanic glass that forms during eruptive activity, frequently within pyroclastic flows. The composition of obsidian can range from basaltic to rhyolitic, though predominantly is formed in more silicious (rhyolitic) and thus more explosive volcanism. The composition of obsidian reflects the initial melt composition and thus is typically consistent throughout individual flows.

Obsidian is conducive to *in situ* analysis due to its very fine grainsize and homogenous composition, therefore representative analyses can be arrested from non-destructive irradiation of the surface of artefacts and rock fragments.

Melanesian obsidian artefacts have been successfully sourced to their original flows using PIXE-PIGME analysis (as discussed in Bird et al. 1997). Element ratio plots and principle component analyses have been used to compare artefact compositions with source compositions to identify source area characteristics.

Several characteristics of Melanesian obsidian sources have been determined using PIGME analysis (www.ansto.gov.au/ansto/environment/iba/projects/archaeology.htm) including:

1. Admiralty Islands obsidian has high fluorine content
2. New Britain obsidian has low sodium and fluorine content
3. Vanuatu obsidian has high aluminium and low fluorine content

2.2 Chert

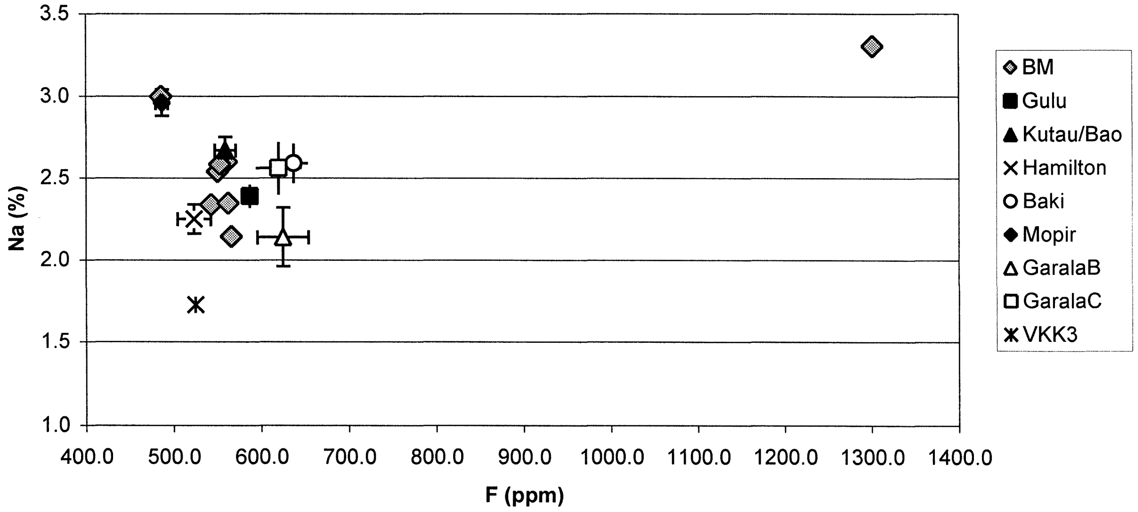
Chert is a fine-grained, generally vitrous, silicious rock that is typically formed by the deposition of diatoms and other silicious organisms including sponge spicules onto the sea floor, followed by burial and lithification. This process can form both thick chert units and thin lenses within limestone units depending on the depositional environment. In addition to biogenic formation chert can also occur as a result of hydrothermal processes.

Several factors associated with the rate and timing of chertification contribute to physical differences within single units (Behl and Garrison 1994) and therefore cherts are not necessarily homogenous. Thorough investigations of chert occurrences are thus required before any sourcing analysis can be undertaken in a region. A pilot study (Chert geochemistry and fingerprinting of terranes. Dr P. W. G. Tanner, Dr H. A. Armstrong University of Durham with Dr G. Warren, Univeristy College Dublin & Dr N. Finlay) is being undertaken to demonstrate the use of geochemistry in provenance analysis of Scottish archaeological radiolarian chert artefacts with extensive sampling and analysis of well-documented formations (e.g. Owen et al. 1999). The results of projects such as this, using the latest analytical technologies, will lend to successful investigations of chert sourcing in other locations.

The sample size and the knowledge of local chert formations for this study are both insufficient to be able to positively identify source localities for the artefacts found at Buang Merabak. Further geological field investigations and a major sampling and analysing program could potentially yield significant results. Typically Rare Earth Elements are used to determine characteristics of chert formation as they are highly immobile and thus, different techniques that are tailored to analyse predominantly for REE compositions, such as ICP-MS laser ablation techniques, would also benefit a sourcing program.

3.0 Buang Merabak obsidian origin

Bivariate plots of trace elements known to be characteristic of source locations within Melanesia are presented in Figure 1. The 8 obsidian artefacts appear to fall into 4 distinct groups. Two clusters containing 3 artefacts and two single outliers. The comparative source data presented on the graphs is taken from Bird et al (1997) and indicates that three of the groups are likely to have been sourced from New Britain. Specifically the sources appear to be, Katau/Bao and Gulu or Hamilton areas on Willaumez Peninsula and Mopir, all in west New Britain (locations shown in Bird et al 1997, figure 2, pp. 63). The remaining outlier not attributed to the New Britain source locations has high fluorine content typical of the Admiralty Group obsidians, however no data is available for comparison.



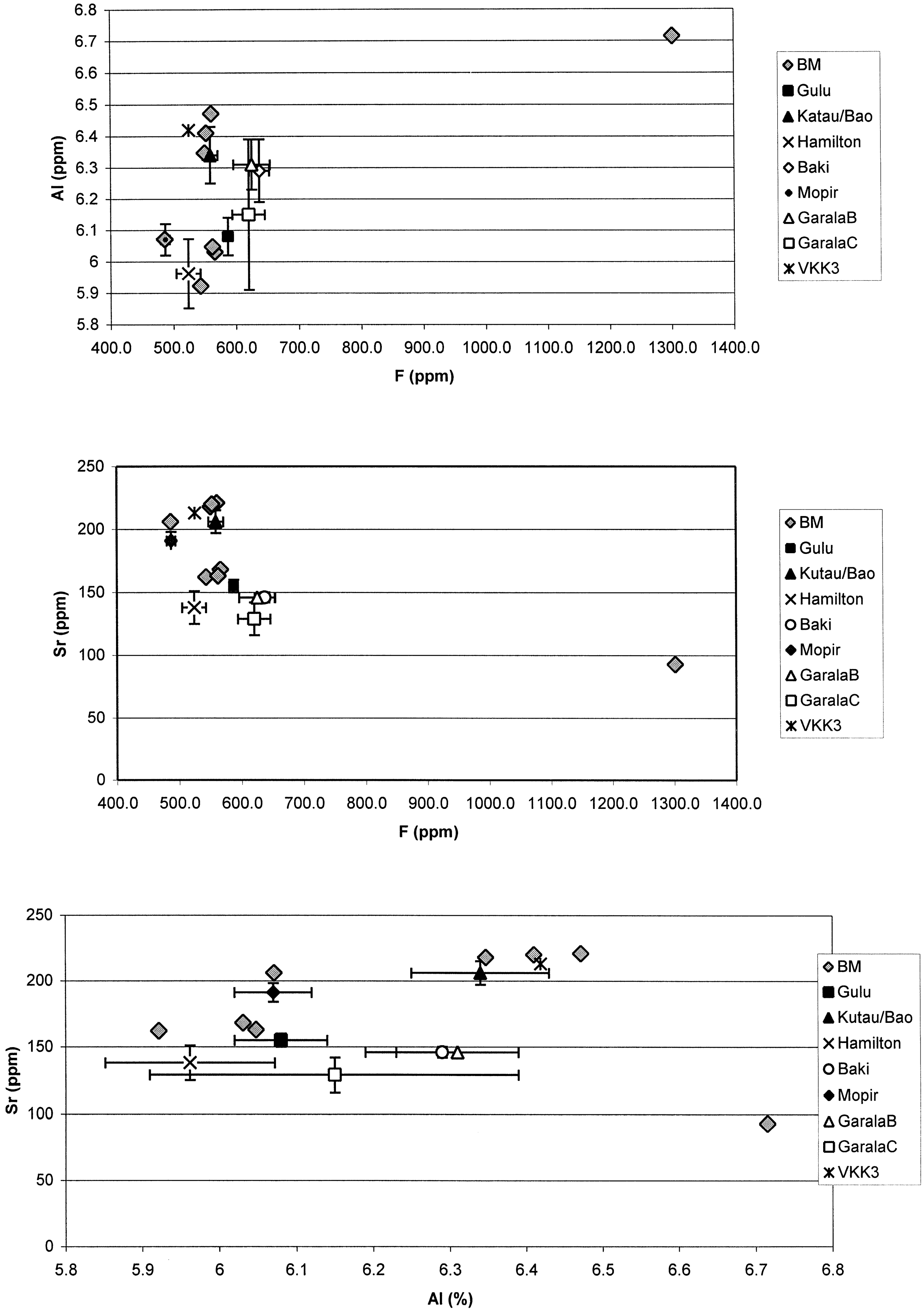


Figure 1 Four bivariate element plots of Fl, Na, Al and Sr for the obsidian artefacts collected at Buang Merabak (BM) and Valtakuikui (VKK). Representative New Britain obsidian source data are also presented with error bars (data from Bird et al, 1997).

The element ratio plot (Figure 2) presents the data as ratios of Aluminium and Sodium compared to Fluorine and Sodium. Also plotted on the diagram are compositional zones for samples from the New Britain and Admiralty Islands as recorded at the ANSTO laboratories (www.ansto.gov.au/ansto/environment/iba/projects/archaeology.htm). The high fluorine Buang Merabak sample falls within the composition zone for the Admiralty Islands group.

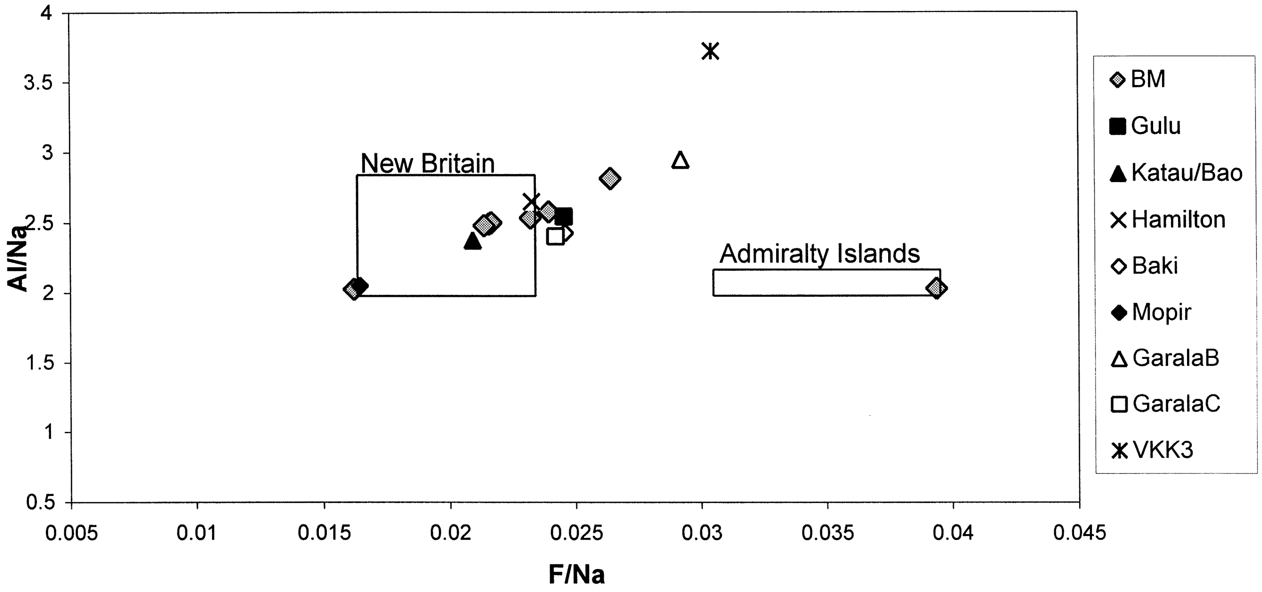


Figure 2 Al/Na and Fl/Na element ratio plot for obsidian artefacts at Buang Merabak (BM) compared to source data ranges for New Britain and the Admiralty Islands obsidian from the ANSTO Laboratories and data from Bird et al., 1997.

In conclusion, the Buang Merabak obsidian artefacts are predominantly sourced from New Britain with a minor contribution from the Admiralty Islands.

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Appendix 12

Buang Merabak Shell Analysis

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Introduction

The purpose of this study was to investigate the nature of change within the Neritidae family that was thought to represent continuity over time in the Buang Merabak shell assemblage. The results of Balean's (1989) analysis indicate that the early layers contained a narrow range of large individual shells and the later layers contained smaller individual shells from a wider range of taxa while Nerita sp. were constant throughout all layers (Balean 1989; Rosenfeld 1997). This study focuses explicitly on the *Nerita* sp. taxa in order to determine whether they too changed over time.

Method

The Buang Merabak assemblage has four units representing the period from 39,590 bp until 1800 bp. One spit was selected from each Unit in order to investigate change over time. The relationship between the spits and Units is expressed in table 1.

Table 1: Units of TP1B of Buang Merabak used in the study (after chapter 3)

Unit	Spits per Unit	Spits selected for this analysis	Age bp. per Unit
1	1 - 8	8	1800 – 3500
2	9 – 17	15	7,000 – 12,000
3	18 - 27	27	17,000 – 20,000
4	27 – 39	34	27,000 – 39,500

The shell content of each spit had been separated from other material in the field. The samples in general were highly fragmented and included relatively few complete shell specimens, and the older levels of the samples included specimens that were heavily encrusted with deposits of lime. Because of age and bleaching over time, traces of shell colour were only evident in the most recent spit (spit 8) so consequently colour could not be used in the classification process. For the purposes of analysis the shells were initially separated into broad categories, with *Nerita* species being separated from other gastropods and other marine specimens. The *Nerita* specimens were then divided into species. The speciation was carried out on the morphology of the shells and in particular noting other characteristics such as aperture structure and surface striations. Fragments were classified according to species on the basis of diagnostic characteristics such as surface striation, columella plate construction and teeth and aperture. Once they were classified to species they were weighed and counted. These data are tabulated in Table 2 below.

Table 2: Neritidae identified in shell samples in Spits 8, 15, 27, and 34 TP1B Buang Merabak.

Spit 8	Wt. (gm)	% of total wt	NISP	% of NISP	Ave wt. (gm)
N. albicilla	1.5	1.6	1	0.6	1.5
N. polita	34.7	36.3	35	22.4	1.0
N. costata	12.1	12.7	9	5.8	1.3
N. plicata	25.7	26.9	51	32.7	0.5
Nerita sp. fragments	6.5	6.8	9	5.8	0.7
Nerita opercula	0.4	0.4	2	1.3	0.2
Clithon oualaniensis	14.7	15.4	49	31.4	0.3
Total Neritidae	95.6	100	156	100	0.6
Total Other Shell	1200.8				
TOTAL SHELL	1296.4				
Neritidae as proportion of shell per spit		7.4%			
Spit 15	Wt. (gm)	% of total weight	NISP	% of NISP	Ave wt. (gm)
N. polita	41.2	23.8	58	14.5	0.7
N. costata	44	25.4	56	14	0.8
N. plicata	71.8	41.4	221	55.3	0.3
Nerita sp. fragments	12.5	7.2	48	12	0.3
Nerita sp. opercula	0.6	0.3	4	1	0.2
Clithon oualaniensis	3.3	1.9	13	3.3	0.3
Total Neritidae	173.4	100	400	100	0.4
Total Other Shell	976				
TOTAL SHELL	1149.4				
Neritidae as proportion of shell per spit		15.1%			
Spit 27	Wt. (gm)	% of total weight	NISP	% OF NISP	Ave wt. (gm)
Nerita *N. polita*	148.5	16	155	10.2	1.0
N. costata	64.7	7	68	4.5	1.0
N. plicata	581.6	62.8	1111	72.9	0.5
N. undata	29.4	3.2	34	2.2	0.9
N. cf undata	36.8	4	72	4.7	0.5
Nertitdae opercula	3.1	0.3	9	0.6	0.3

Neritidae fragments	9.3	1	62	4.1	0.2
specimens heavily encrusted	52.7	5.7	12	0.8	4.4
Total Neritidae	926.1	100	1523	100	0.6
Total Other Shell	920.8				
TOTAL SHELL	1846.9				
Neritidae as proportion of shell per spit		50.1%			
Spit 34	Wt. (g)	% of total weight	NISP	% of NISP	Ave wt. (gm)
Nerita *N. polita*	119.5	28.9	71	18.3	1.7
N. costata	64.1	15.5	51	13.1	1.3
N. plicata	183.7	44.5	215	55.4	0.9
N. undata	12.2	3	13	3.4	0.9
N. cf undata	33.7	8.2	37	9.5	0.9
Nertitdae opercula	*	less than 0.1g	1	0.3	*
Total Neritidae	413.2	100	388	100	1.1
Total Other Shell	2278.2				
TOTAL SHELL	2691.4				
Neritidae as proportion of shell per spit		15.4%			

Each taxa has particular ecological characteristics that indicate which part of the littoral zone they prefer and this information is set out in Table 3 below.

Table 3: Neritidae identified in spits together with usual habitat (Wilson, 2002)

Taxa	**Habitat**
N. albacilla	Sheltered positions on intertidal zones; rocky shores.
N. polita	Middle intertidal areas; rocky shores
N. costata	High tide levels and below
N. plicata	High tide levels and below
N. undata	Occurs high on the shore of mud and rocky habitats in brackish, muddy waters.
Clithon oualaniensis	Prefer slow moving, sheltered shallow water on rocky shores

Discussion

The shell assemblage indicates regular usage of shellfish over the life of the site (39,590 bp to 1800 bp). Shell appears at all levels, there is steady decline in the total weight of shells over time. While shell the total shell declines with time the average size of Nerita sp. remains steady suggesting that there is not a trend towards the collection of smaller individuals over time. This suggests that the quantity of shellfish brought to the site reduces over time. The results in figure

1 indicate that *Nerita* sp. consist of less than 15% of total shell for spits 34, 15 and 8. However, they consist of 50% of spit 27. *Nerita plicata* consist of 72% of all *Nerita* sp. in spit 27.

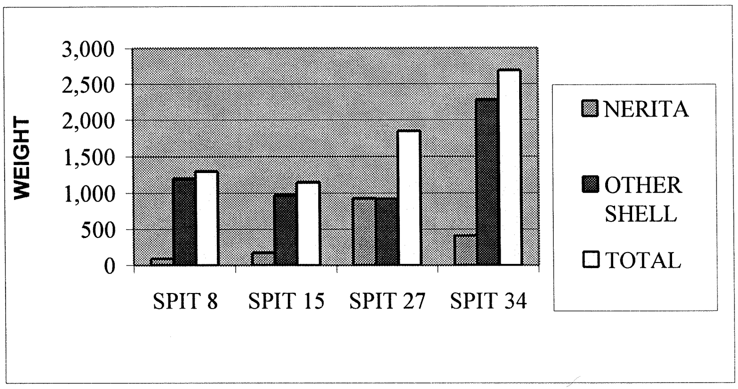

Figure 1 Weight (gm) per taxa per Unit.

The results in figure 1 indicate that *Nerita* sp. decreased after spit 27 as a proportion of the shell per spit over time. They were 15% of spit 34 and increased to 50% of spit 27 before returning back to less that 15% in spits 15 and 8. However, the proportion of *Nerita* sp. in spit 27 shows a 300% increase compared to spit 34. Therefore the pattern for the results for Nerita sp. is an increase from spit 34 to 27 and then a gradual decrease through spit 15 to spit 8.

The results in table 1 demonstrate the importance of *N. plicata* to the assemblage. It contributed more than half of all *Nerita* sp. in spits 34 and 27 and more than 20% of spits 15 and 8. In the context of Balean (1989) it was the *N. plicata* that represented continuity over time rather than the genus Nerita in general.

After spit 27 the contributions per taxa began to even out. *Nerita plicata* was regularly collected, but by Spit 8, there had been an decline in the use of this species. Other species that came in after N. albicilla, *N. polita*, *N. costata* and *Clithon oualaniensis* increase in their relative contributions. The results suggest that the relative contribution of these taxa expanded within an overall pattern of contraction. This is not apparent in Balean (1989:5Gii) in which the overall contribution of *Nerita* sp. is contracting over time.

Conclusion

Over the whole period, it appears that shell fish were regularly consumed by those using the cave. The *Nerita* sp. expand in their contribution to the assemblage and were 50% of spit 27 in which *N. polita* was dominant. After spit 27 the *Nerita* sp. the contribution of other Nerita sp. taxa increase over time.

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