

HIGHLAND NEW GUINEA
HUNTER-GATHERERS:
THE EVIDENCE OF
NOMBE ROCKSHELTER, SIMBU
WITH EMPHASIS ON THE
PLEISTOCENE

by
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A thesis submitted for the Degree of Doctor of Philosophy
of the
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Plate 1 Waivo, son of Papa Noibano the traditional owner of Nombe, against the strike ridge above Nombe, which is in the trees at the bottom of the cliff. Taken from Keu Hill at about 2400 m asl.



Plate 2 View of the site of Nombe in 1971 showing the main walking track along the cliff base to the south of the site.

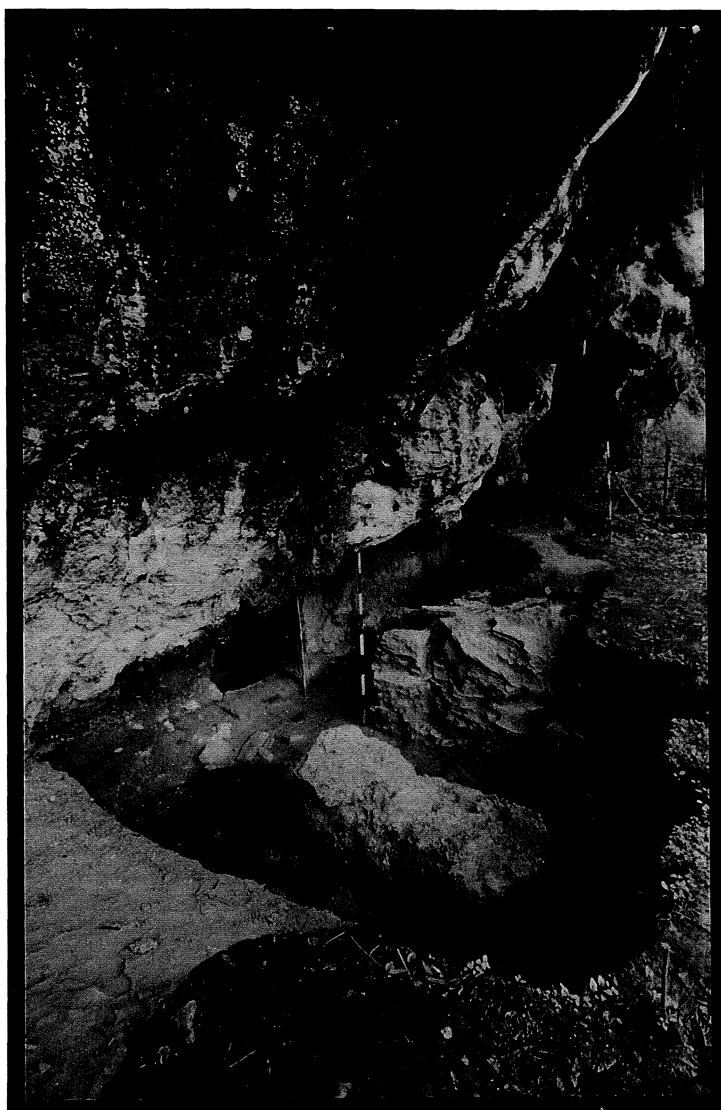


Plate 3.
Excavations
in progress
during 1979.

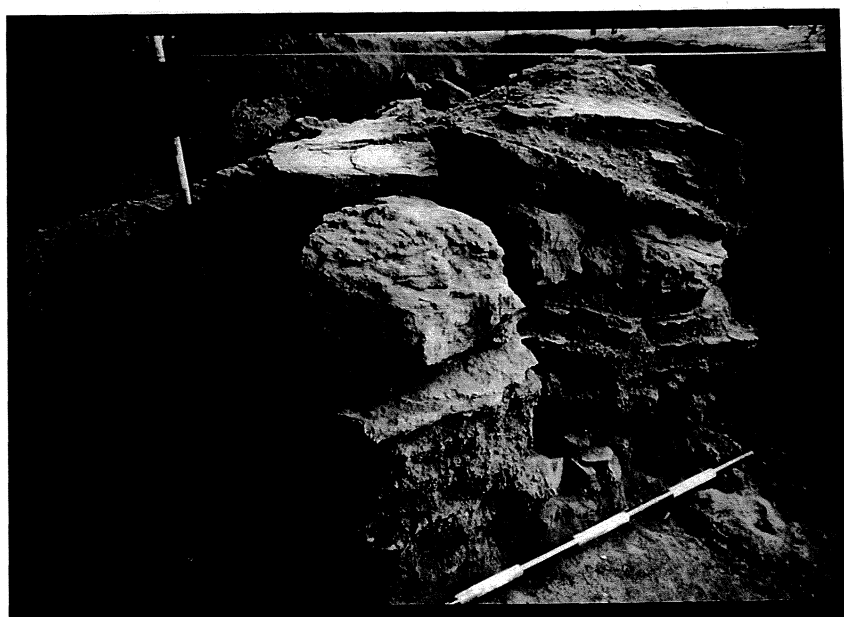


Plate 4. Blocks of tephra sandwiched between sheets of flowstone (see Profile 1)
December 1979.



Plate 5. East face of square X3 showing the distinction between strata A and B (dark brown sediments), Stratum C (white flowstone and pale blocks of tephra) and Stratum D (redbrown clays – pale in photo) containing chunks of limestone (See Profile 6 volume 2).

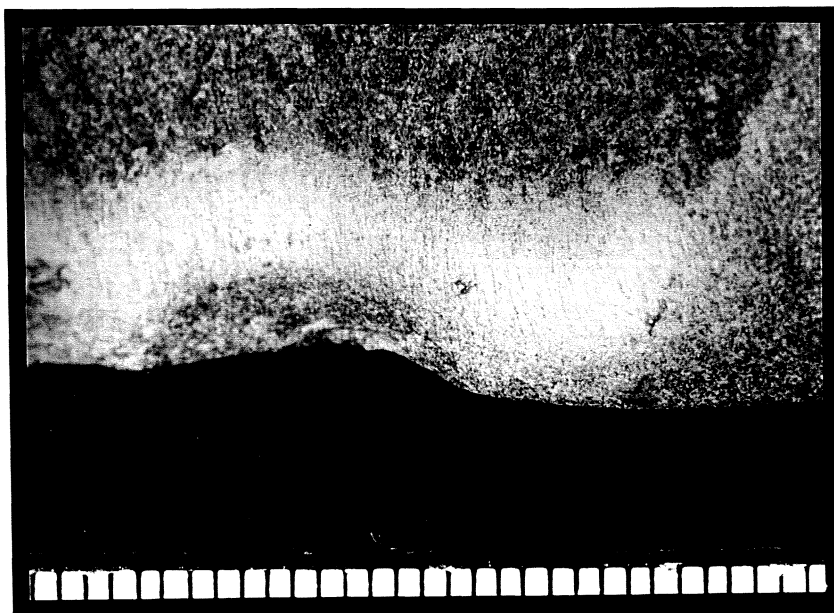


Plate 6 Close up of edge ground axe from Stratum D1/5, showing striations parallel to edge. (Photo: D. Markovic.)



Local villagers with
David Gillieson
and Mary-Jane
Mountain at the
Nombe
excavations,
November 1979.

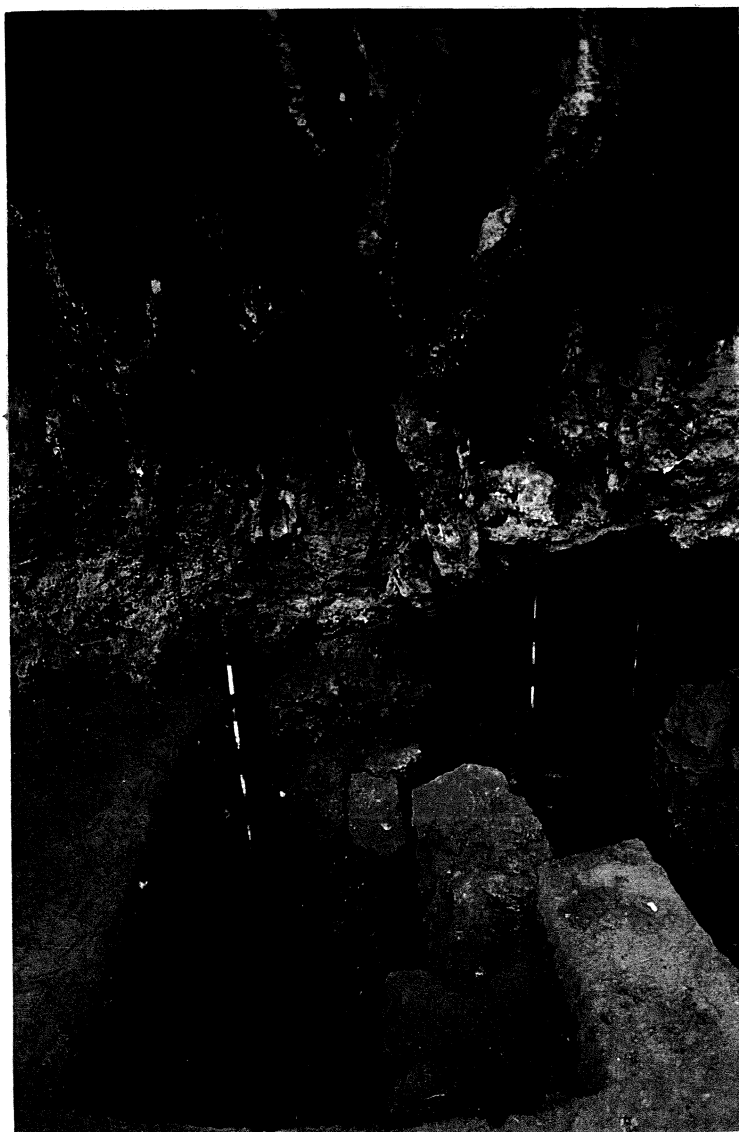


Plate 8.
Excavations before
the Consolidated
Block was removed
in 1979.



Plate 9. Profile A5-A6 showing tephra blocks sandwiched between flowstone sheets, the lowest of which lies directly on the top of the redbrown clay.

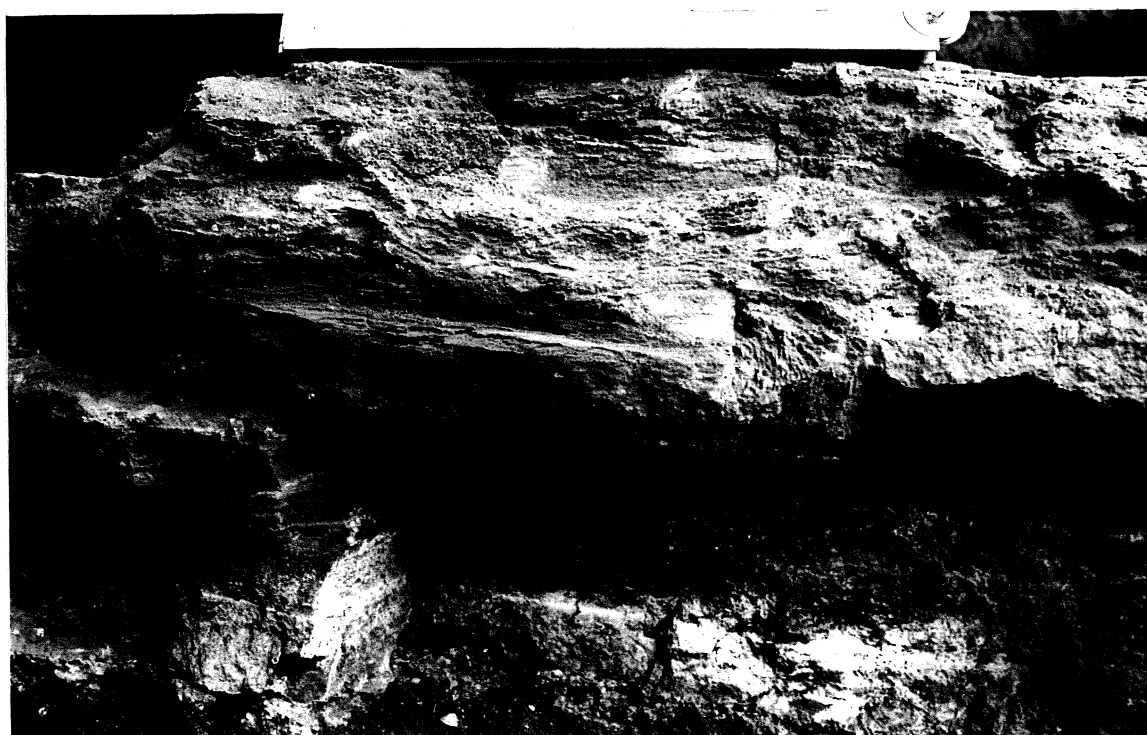


Plate 10. Tephra block in A5. The upper regions may be mixed with fine ash.



Plate 11. Vertical view of flowstones in squares B4 and C4 from above and showing rim of gour pool.

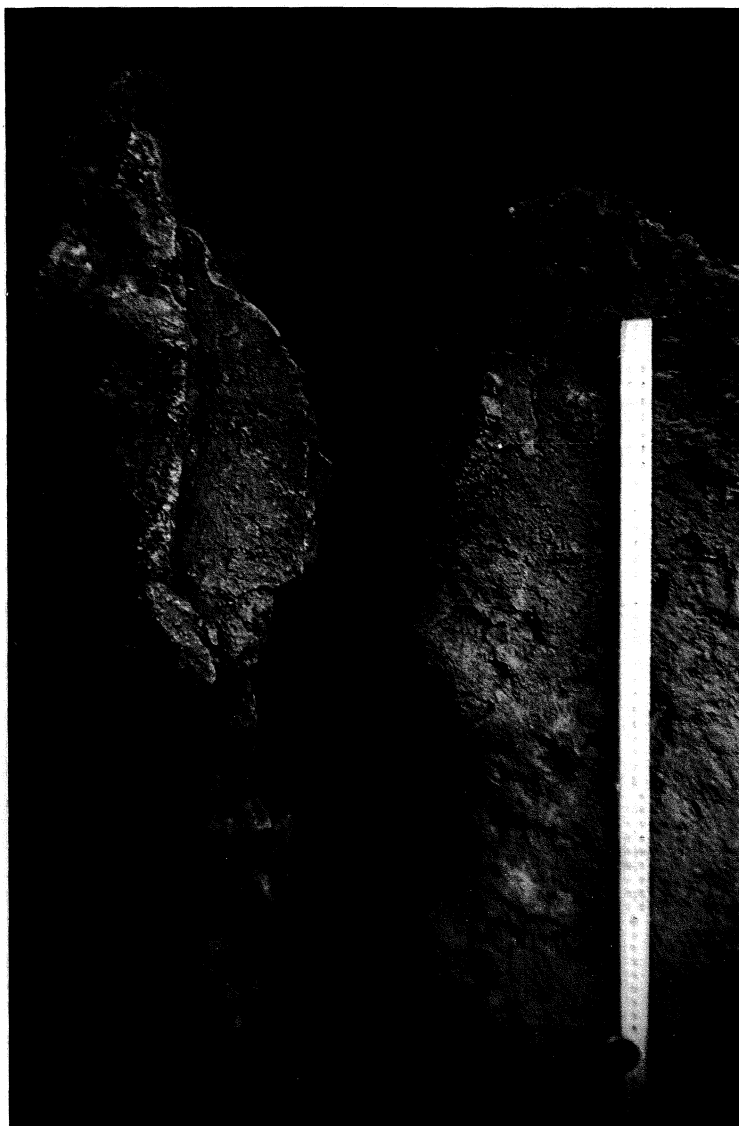


Plate 12. Close-up of gour pool rim on flowstones in square B4.

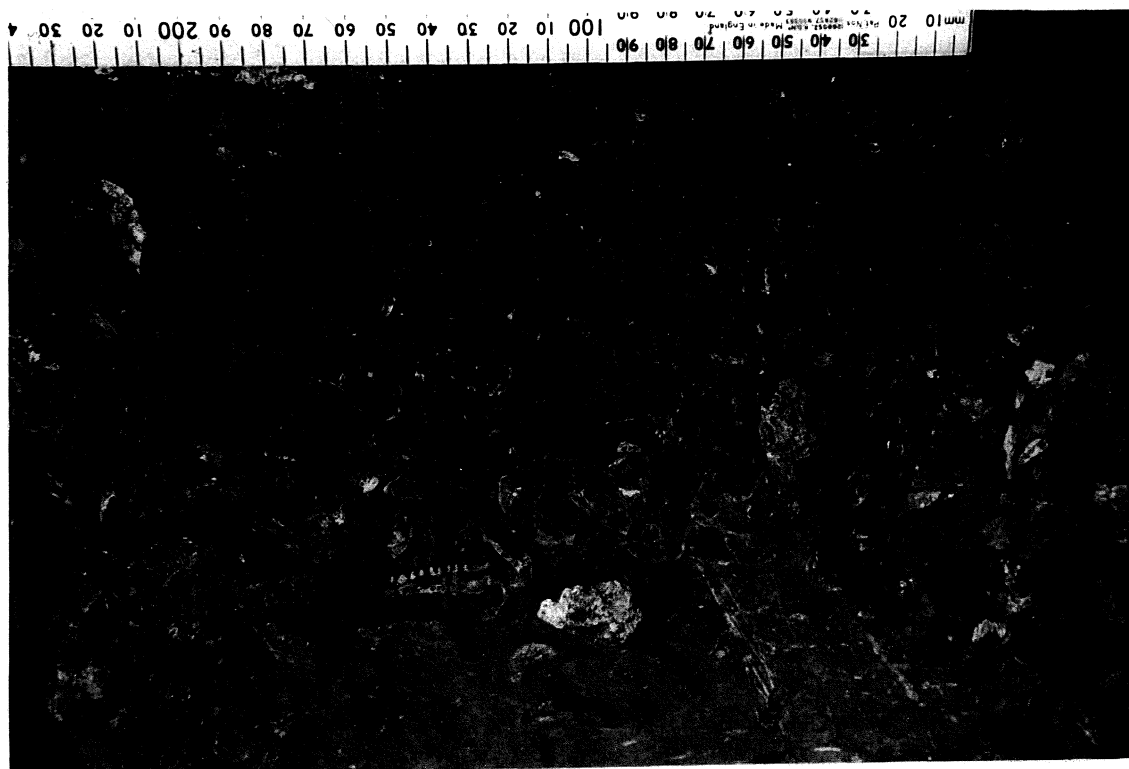


Plate 13. Archaeological debris cemented onto the top of the fallen limestone block in the Trial Trench area.



Plate 14. Edge-ground axe from Stratum D1/5 (Photo: D. Markovic)

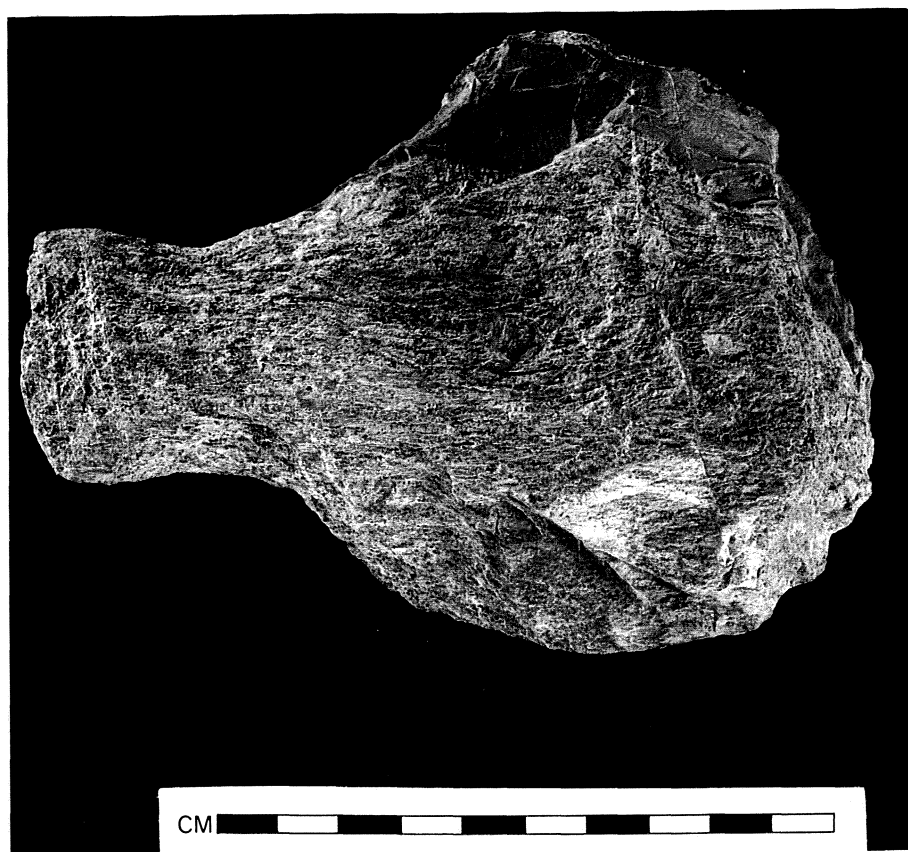


Plate 15. Waisted artefact from Stratum D1/5 (Photo: D. Markovic)

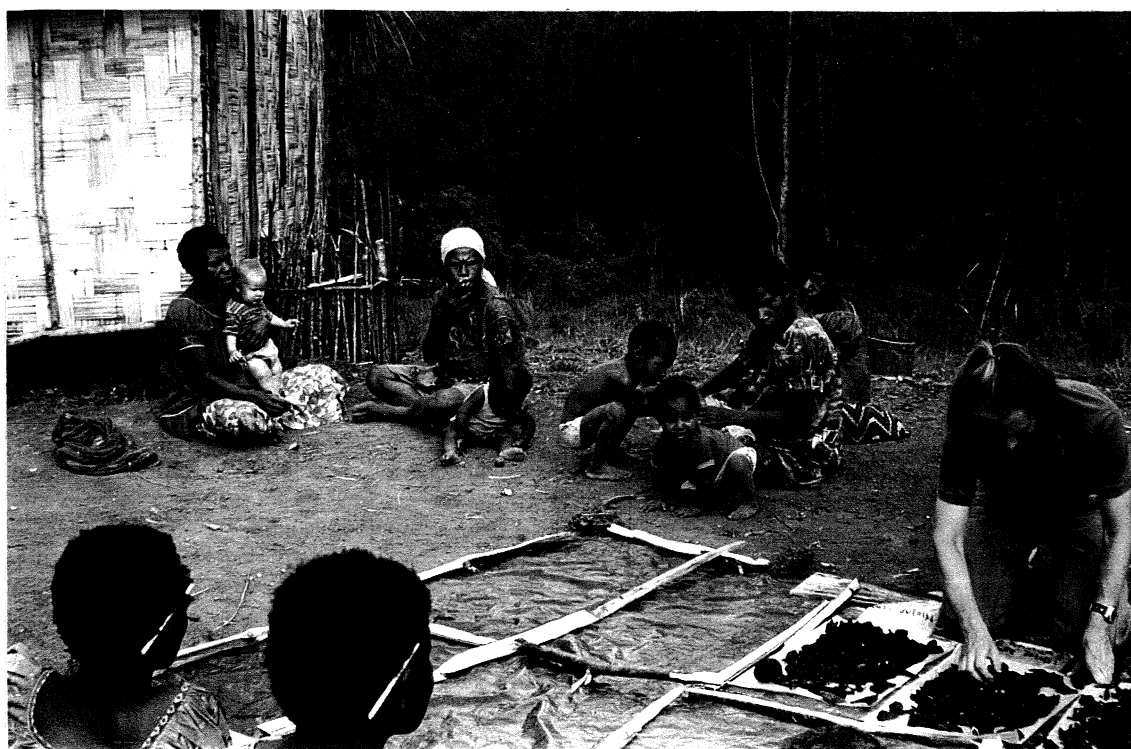


Plate 16. Drying wet-sieved material at Nongefaro Village.

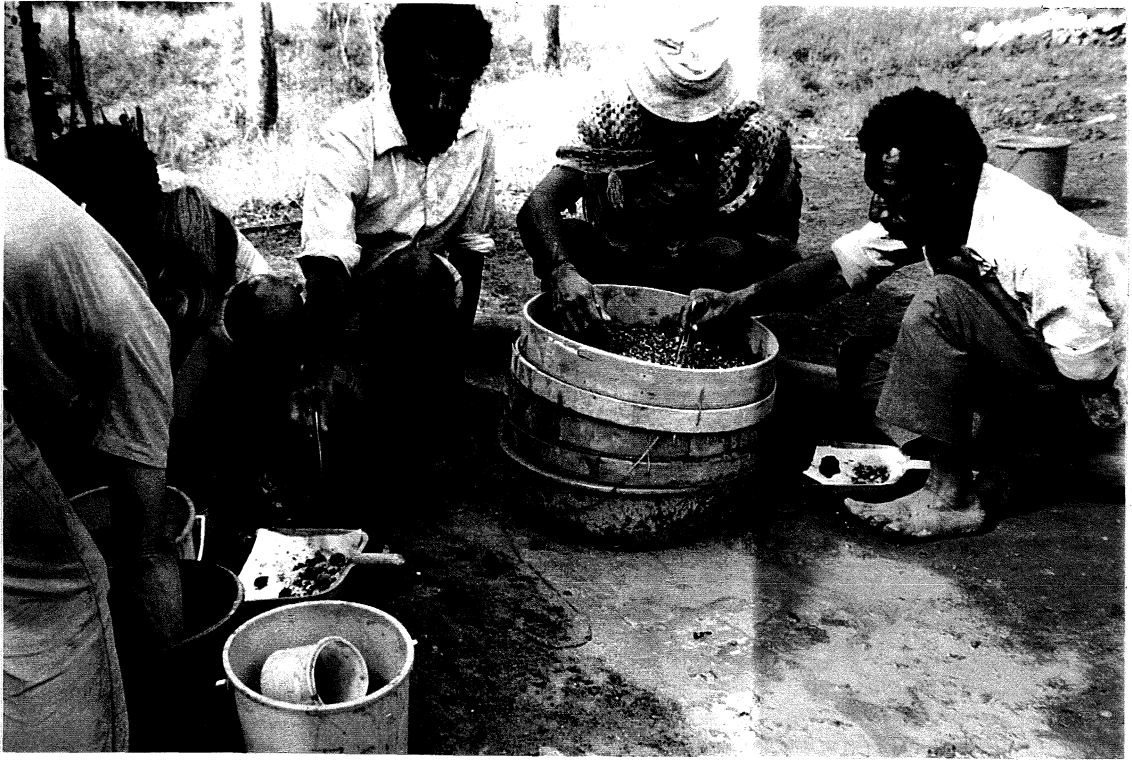


Plate 17.
Sorting wet-
sieved
material



Plate 18.
Site survey
on Mount
Elimbari, 1979.

Chapter 1

Introduction

1.1 RATIONALE

A study of bones is however, not sufficient to clarify our ancient past. We must know how to use information and organise research, and we must increase the reliability with which we construct the past. Binford (1981:1)

This thesis is basically about bones and the ways in which archaeologists use them to provide information through which to construct a version of the past. Binford showed that such data and the associated research methods were far from satisfactory in the period before 1981. His work, of which *Bones: Ancient Men and Modern Myths* published in 1981 is one of the most important, has been a prime example of how accepted traditional methods have been examined and found to be inadequate. Binford has shown several ways in which the archaeologist can evaluate bones as a major source of archaeological data and has provided examples of new ideas. Brain's seminal book *The Hunters or the Hunted?* is another example of a reassessment of old theories, leading to re-analysis of data and the production of a 'new prehistory'.

Research in this tradition on Pleistocene sites and data from many parts of the world has identified many incorrect assumptions that caused errors in earlier interpretations (e.g. Turner 1981a, 1981b; Gamble 1979, 1983, 1986, 1987). Turner has been concerned with the lack of appreciation of the role played by the large carnivores in bone accumulations at sites long accepted as the domain of Palaeolithic hunters. Gamble (1979) re-analysed the remains from several Pleistocene sites in central Germany, concluding that human activity was only marginally concerned, if at all, in the accumulation of bones in a number of Middle Palaeolithic sites which had previously been interpreted as part of a cult of the European cave bear. In his masterly survey of the Palaeolithic settlement of Europe, Gamble (1987) provided a new perspective in Palaeolithic interpretation, moving away from the rigid typology of stone artefacts towards an assessment of how people had adapted to the exigencies of late Pleistocene environmental change through social and cultural strategies.

It is not only new research that changes ideas and the pattern of research. A week before this thesis was completed, I finally obtained a copy of Weigelt (1989). It is the book I wished I had written, it being one of the most thoroughly researched taphonomic analyses of bones. The collection of data, through a program of fieldwork,

is comprehensive and scrupulous. The analysis concludes with a series of conclusions or laws, which can be tested by those of us with a fascination for the process of decay and the translation of a rather bloody and pathetic carcass into a pattern of archaeological bone. Yet this book was written in 1927 by Johannes Weigelt, a German scientist who studied death on the Texas coastal plains, and which only became available in English 65 years later as *Recent Vertebrate Carcasses and their Paleobiological Implications* (Weigelt 1989). As one reviewer has said, 'It is perhaps the most significant volume concerning taphonomy to be published in the 1980s'. Taphonomy is a vital element of the research presented in this thesis.

1.2 THE RESEARCH PROJECT

This thesis grew out of fieldwork, excavation and the data recovered. I was an archaeologist investigating a site with a problem common to archaeologists, that of complex stratigraphy: stratigraphy that was indeed so complex that the previous excavator (White 1967), unable to spend further time at the site, had decided not to have any radiocarbon samples analysed since he thought the results would have been of little assistance in understanding the abundant data recovered from the site.

Only two professional archaeologists had worked in the highlands of Papua New Guinea before the beginning of this project in 1971. S. E. Bulmer had carried out an extensive survey of archaeological sites from the Baiyer River valley in the Western Highlands to the Chuave area of what was, in 1959/60, the Eastern Highlands. Her MA thesis (Bulmer 1966/1976) includes information on two excavations which she carried out at Yuku rockshelter, Western Highlands and Kiowa rockshelter, Simbu Province. Following this, White undertook further surveys and more extensive excavations in 1964, in Simbu and further east, for his doctoral thesis (White 1967, 1972). White subsequently also excavated at the open site of Kosipe, Central Province (White, Crook and Buxton 1970), dating some of the recovered stone artefacts (including several waisted artefacts) to a period before the glacial maximum of c.18,000 bp. This occupation, at c. 26,000 bp was the earliest evidence for human occupation of the highlands.

My field work commenced in October 1971. I was joined by Ian Saem Majnep (at that time of the Department of Anthropology and Sociology, University of Papua New Guinea) as archaeological assistant and interpreter. The project involved a re-investigation of two Simbu rockshelters that had already been examined by White, both of which had produced interesting and plentiful data but had major stratigraphical or chronological problems. During this re-investigation, data were collected from one site, Nombe, that suggested early human occupation. A waisted artefact similar to the Kosipe examples and an edge-ground axe of the type shown by Carmel White (Schrire 1982) to go back into the late Pleistocene in northern Australia,

were recovered from levels below the base of White's excavations. Even more interesting was the discovery of bone from extinct Pleistocene species (first recognised by J. Hope and later identified by Flannery (Flannery, Mountain and Aplin 1983) in the same sediments as the artefacts as well as in the very basal sediments of the excavation.

This was not the first time that an archaeological site in highland New Guinea had produced such bone. White had recovered a tooth of an extinct macropodid in the lowest levels of Kafiavana (White 1972; Plane 1972) but since this was below the level of the first human occupation, it was presumed that there was no connection with human activity. Bulmer had recovered thylacine (*Thylacinus cynocephalus*) in levels with clear evidence of human presence at Kiowa (Bulmer 1966/76; Van Deusen 1963). But the evidence recovered during the 1971 excavation season at Nombe was far more extensive than at either of those sites. Several different species were present in the clays at the bottom of the site. Higher in the site the suite of animals clearly altered. In Stratum B, which contained evidence for intensive human occupation, (White had ceased to excavate at the bottom of this level), the fauna appeared superficially to be similar to the range of animals expected in highland regions today. The relationship between the fauna, the natural environment and human activity interested me because of the intensifying debate on this relationship evident, for example, in the work of Binford (1981), Gamble (1979), Clarke (1976) and Isaac (1981). If the site's stratigraphical and chronological complexities could be solved, it was clear that the Nombe faunal data had the potential to make a substantial contribution to the debates on the complex relationship over time between humans, animals and the environment.

The project developed in the early 1970s as a personal research project funded by the University of Papua New Guinea. A group of prehistory students and staff from the Department of Anthropology and Sociology worked with me at the site in 1974 and 1975. Although a great deal of progress was made in understanding the stratigraphical problems, it was clear that further research on the sediments and their chronology would be required for a real understanding of site development. Faunal analysis could only be successful if a great deal of time was devoted to identification; no adequate faunal collections were available in Papua New Guinea. The research project was accepted as a doctoral thesis topic by the Australian National University in 1978.

1.3 AIMS

There are two main areas of research interest that can be pursued through an analysis of the Nombe data, and can be phased in the form of questions.

- How have the human populations of the highlands increasingly imposed their way of life on the landscape during the last 10,000 years? The documented modern ethnographic variations have their roots in prehistoric human activity

and Nombe could contribute to the debate about the history of hunting/collecting in the Holocene in the context of the effects of agricultural activity on the progress of forest clearance and the development of grasslands. A detailed analysis of the data from the Holocene strata (A and B) at the site would provide evidence relevant to these areas of debate, including the question of the introduction of the exotic animals, namely the pig and the dog.

- What was the nature of the prior relationship between human beings and their natural environment within one region of the highlands of New Guinea? Relevant to this debate would be the analysis of the data recovered from the Pleistocene strata at Nombe (D and C). What was the environment like before humans arrived in the highlands and could the first modifications of that environment for human benefit be documented?

Given the complexities of each of these broad topics, it was not going to be possible to cover both in the thesis research. Since Nombe was apparently unique as a site of Pleistocene occupation, I judged the second question more important. I also found it more challenging. It required deducing evidence about the earliest stages of the relationship between human populations and their environment. Unlike many other parts of the world where various species of hominid existed at earlier times, New Guinea provides an example of the immediate and direct exploitation by *Homo sapiens* of a previously untouched environment.

Human hunting and collecting had their effects on that environment from the first arrival of the species, but the nature of the changes effected is far more subtle and their interpretation more controversial than in later periods of prehistory. Hunter-gatherer activities are often seen by members of our ecologically destructive generation as representing an ideal balance between environmental supply and human dependence. But wherever the human race has been successful, it has inevitably expanded, developed new technologies, spread into neighbouring territory and, over thousands of years, changed the environments into which it has moved. Documenting the early stages in this relationship in the New Guinea highlands would not be straightforward and the interpretations would be open to challenge. Nevertheless, the pursuit of the question was important and the necessary techniques and choice of appropriate analyses were challenging.

The research was therefore structured to study three broad but related issues.

- **The nature of the relationship between the early human occupants of the highlands and the environment in which they became participants.** When people first entered the highlands of New Guinea, about 30,000 years ago or more, they entered a landscape affected by the lower temperatures of the late Pleistocene. Hope and Hope (1976) had suggested that human hunters were attracted to the alpine grasslands and shrub-rich forest edge which constituted

a resource zone particularly for hunting that virtually disappeared with the warmer temperatures of the Holocene. Could data from Nombe be used to test this theory?

- **The contentious issue of Pleistocene extinctions and the role of human beings in that process** (Martin 1967; Martin and Klein 1984). The recovery of bones of extinct species in levels containing evidence for human presence at Nombe offer an opportunity to look at this issue at a new site.
- **The nature of the transition from hunting and gathering to horticultural subsistence.** All highland societies today are horticultural and derive little of their basic subsistence from the activities of hunting and gathering in their heavily impacted environments. In their rockshelter excavations neither Bulmer nor White had identified any specific change in stone technology that reflected a change in the subsistence economy, although Bulmer (Bulmer and Bulmer 1964) certainly identified the arrival of the ground stone axe-adze as heralding the beginning of agriculture. White (1972:147) could see no major artefactual change after the initial settlement of the region 'for some considerable time, until at least 4000 bp'. He concluded that his overall impression from the archaeological evidence available to 1972

... is one of sameness and continuity. This perhaps indicates only that some basic aspects of life in the Highlands continued unaltered by other economic and technological changes. However it may point to a stability or continuity not often found in post-Pleistocene prehistory. (White 1972:148)

Subsequent archaeological and palynological work in the upper Wahgi valley west of Nombe, provided the basis for claims that horticulture made its appearance in the highlands early in the Holocene and that it had effected marked changes on the vegetation by the mid-Holocene as a result of repeated clearance under a forest fallow regime (Golson 1977; Golson and Hughes 1980). Was it possible in the light of this environmental consideration, that the faunal evidence would be more sensitive than the artefactual evidence to the change in economy?

1.4 METHODS

With the decision to focus on these issues it was necessary to identify the **techniques** that would be necessary to produce appropriate data.

Sediment analysis: The complexities of the Nombe stratigraphy, involving many different sedimentary processes, required the cooperation of a geomorphologist. David Gillieson was then beginning his thesis work on limestone caves in the highlands and was interested in working at Nombe. He visited the field area at the end of 1979 during the last season of Nombe excavations and this cooperation provided both of us with an opportunity to

further our own research projects. His extensive and thorough analyses provided the data that was then interwoven with the stratigraphic record to construct a scenario for the depositional history of the site (Gillieson and Mountain 1983).

Dating: In order to fit the depositional record into a chronological framework, Henry Polach and John Head of the Radiocarbon Laboratory at the Australian National University spent much effort working on the problems of dating a variety of materials from Nombe, including snail shell, bone and flowstones.

Faunal analysis: The analysis of the extensive faunal collections from the excavations forms the backbone of the research. Taphonomic considerations were crucial to this. Clearly there were major variations in the bone material from the Holocene and Pleistocene strata; these variations had to be examined and accounted for before any interpretation could be offered.

There was a great deal of bone to be identified, but there were problems in the employment of conventional 'bone by bone' techniques. Methods of analysis had to be devised that would provide data to allow the examination of the main issues but which could be carried out within the time constraints imposed by the thesis.

Computer analysis: The use of a computer database was essential, but complex decisions had to be made on the classification of the data for computer entry, the programs to be used and the flexibility necessary to enable the testing of the subsidiary hypotheses which would emerge during the research. It is necessary to note that, at the time this data was computerised, the mainframe computers of the Australian National University did not have a suitable database program and the use of computers in archaeology was still in its tentative beginnings.

1.5 LIMITATIONS

There were also a number of **problems** with the site data. Since the fieldwork had commenced in 1971 as a short term project to re-examine stratigraphical and chronological problems, there had been no planning for long term goals. The aims and objectives altered as the project developed and this had repercussions in the recovery and recording of evidence.

- The scale of the excavations became less extensive with each field season and the techniques employed more refined in a bid to achieve a more detailed recovery of archaeological material. This has led to a situation where it has been necessary to amalgamate several sets of data, each on a different level of refinement, in order to present a unified database.

- ❑ Techniques were not specifically designed for the maximum recovery of bone evidence during the early seasons and this had to be rectified during the thesis fieldwork.
- ❑ Certain information was not collected at the beginning of the project; for example, snail shell was not retained in 1971.
- ❑ At the beginning of my first excavations in 1971, there was little stratigraphic differentiation in the top levels and therefore the units of excavation at the time were fairly coarse. However, greater control was required for the thesis work.
- ❑ The re-excavation and backfilling of the site had altered the ground levels on the site, causing recording problems.
- ❑ The location of the site, about 45 minutes walk from the nearest road, caused logistical problems in the removal of evidence (especially heavy blocks of materials consolidated by calcium carbonate) and the cost of transporting material back to Canberra meant that some interesting evidence contained in those blocks had to be left at the site.

In short, a more coherent pattern of research would have been instituted had the continuation of the investigation been foreseen in 1971.

1.6 POSITIVES

A factor that has had a major and beneficial influence on the progress of the research have been the advances made in our understanding of the regional prehistory and knowledge of the highland fauna since the thesis was started in 1978. The ideas and information from these studies have suggested new ways of using the Nombe data and provided a rich background against which to develop the interpretations presented in later chapters.

As Hope and Swadling (1992) have recently said,

the more we discover, the more complex the picture of human-environmental interaction in this remarkable island.

This thesis aims to allow the site of Nombe to make its contribution.

Chapter 2

Locality and Archaeological Excavation

2.1 BRIEF DESCRIPTION OF LOCALITY AND SITE

2.1.1 Topography and altitude

The cave and rockshelter of Nombe is in the Elimbari-Porol Range limestone escarpment (PNG 1:100,000 Topographic series sheet 7985 Goroka). Figure 2.1 shows the location of Nombe within the New Guinea highlands together with other major highland sites. A more detailed local map is included as Figure 2.2.

Nombe is on the eastern edge of a block of limestone bounded to the north by the river Mai and to the east and south by the Movi Beds and the drainage of the River Futoga. To the west the steep scarp slope is dominated by the triangular peak of Mount Elimbari (2850 m). The dip slope is generally fairly gentle. There is little land in the vicinity under 1500 m, apart from the area immediately adjacent to the river at Chuave. Most of the area is between 1600 m and 2200 m in altitude with higher slopes to the east and some limited higher areas on the upper zones of Mount Elimbari itself. The site is at 1720 m on the western edge of the dipslope at 6°10'S, 145°10'E.

2.1.2 Local geology

The Elimbari limestone escarpment is formed from the Chimbu limestone belt of Eocene to Oligocene age, overlaid on the north and east by the Movi Beds which consist of volcanolithic and calcareous sandstones, siltstones, shales and conglomeratic minor cherts (Figure 2.3). The junction between these two formations has become an area for cliffed doline development, and the karst scenery has allowed drainage patterns to develop partial underground systems. The dip slope of the escarpment is crossed by a number of high angle faults, running from the scarp ridge down the slope in a generally north-eastern direction. In areas where the vegetation has been cleared for gardens these strike-controlled ridges are extremely clear.

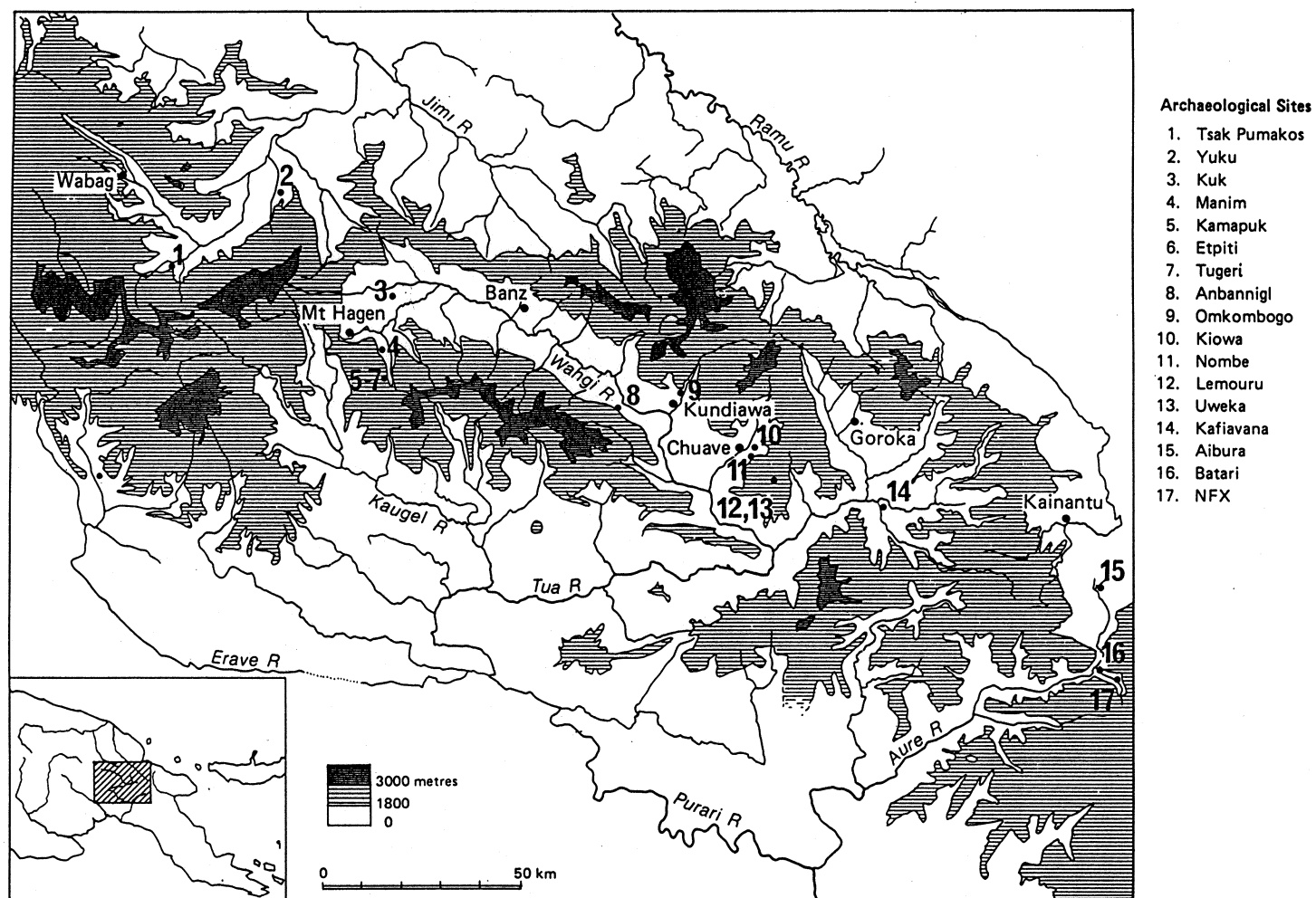


Figure 2.1 Locality map of Papua New Guinea highlands, showing Nombe and other highlands archaeological sites

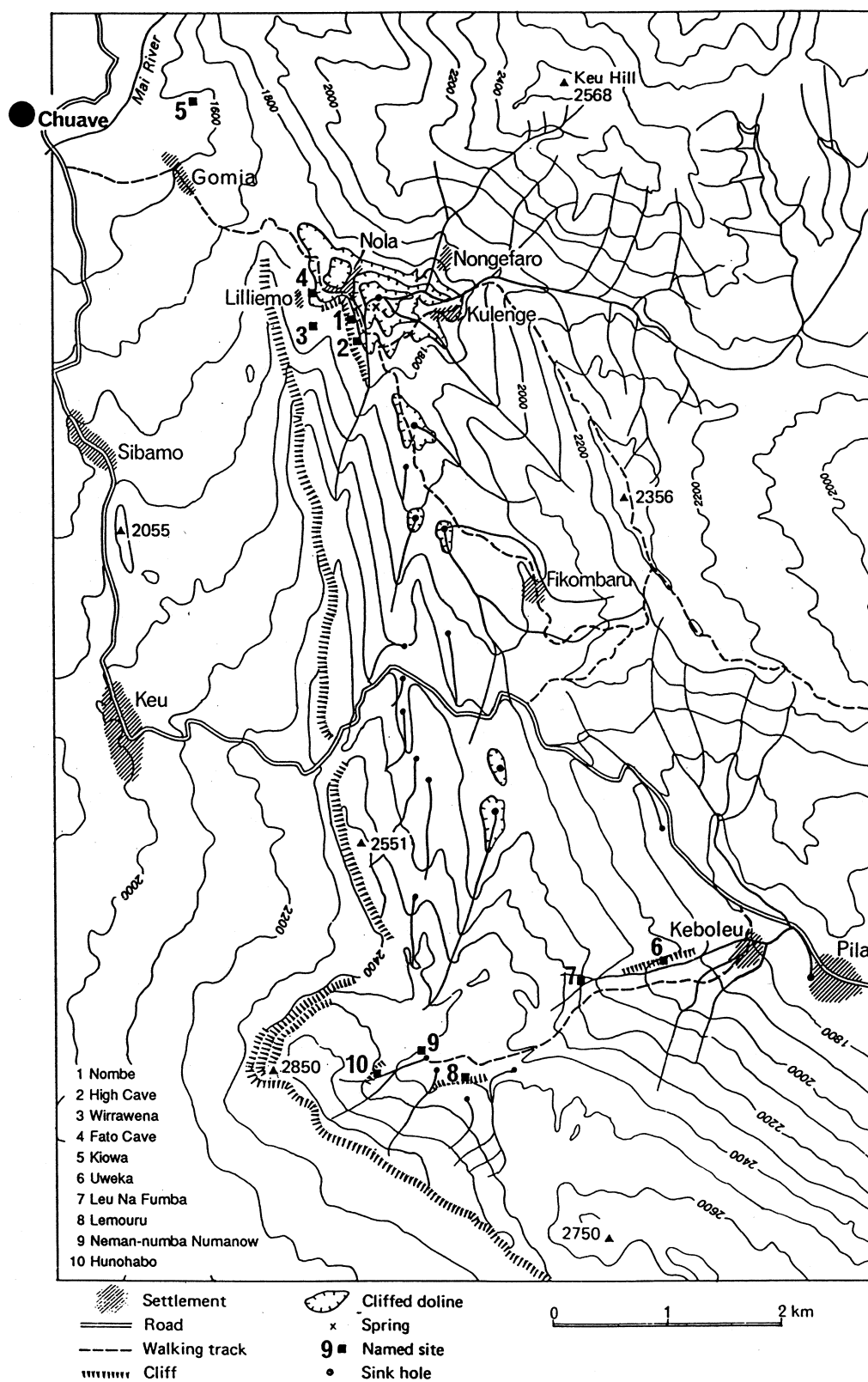


Figure 2.2 Detailed locality map of Nombe

At the time of major uplift of the Elimbari massif, the Movi Beds would have largely overlain the Chimbu limestone but subsequent erosion has stripped away much of the Movi Beds (Bain, Mackenzie and Ryburn 1975). Relict conglomeratic sediments from the mouth of Fato Cave (Figure 2.2), 300 m north of Nombe and on flat saddles between the cliffed dolines near Nola village (found and reported by Gillieson (1982:345)), suggest that the Movi Beds have existed over this area before erosion took place and the streams began to drop underground.

2.1.3 Local drainage

In the immediate area of Nombe, drainage patterns show a general northward flow to the River Mai (also called Mairi and Marifutiga), which flows out of the Bismarck Mountains to join the River Wahgi. The local drainage pattern is shown in Figure 2.4. Over the watershed in the valley east of Mount Elimbari the drainage flows south, to the smaller River Futoga which flows directly into the Tua River. All these rivers eventually join into the Purari River and reach the sea in the Gulf of Papua. Local drainage is irregular due to the karst topography; many streams are seasonal and run only during periods of continuous heavy rain and streams frequently disappear underground and re-emerge further down the slope. The archaeological site of Kiowa is close to a resurgence of a substantial stream and the Lombila doline below Nombe swallows a stream at its base (presumably the same waterway).

Gillieson (1982:345) postulates that an integrated drainage surface must have existed at one time from the east side of Mount Elimbari along the valley in a northerly direction past Nombe and Kiowa down to the River Mai. The subsequent erosion and formation of karst features have caused much of the drainage to go underground leaving an interrupted line of surface drainage. On the karst slopes there are many dolines, for example Wirrawena on the grassland slope above Nombe, and some larger cliffed dolines are found along the drainage routes. There are also caves and rockshelters in the limestone, some, like Fato Cave, of considerable size. While some karst caves still have water flowing through them most are dry for most of the year becoming damp with active water drips during continuous rain, sometimes even with minor streams issuing after extremely heavy rain.

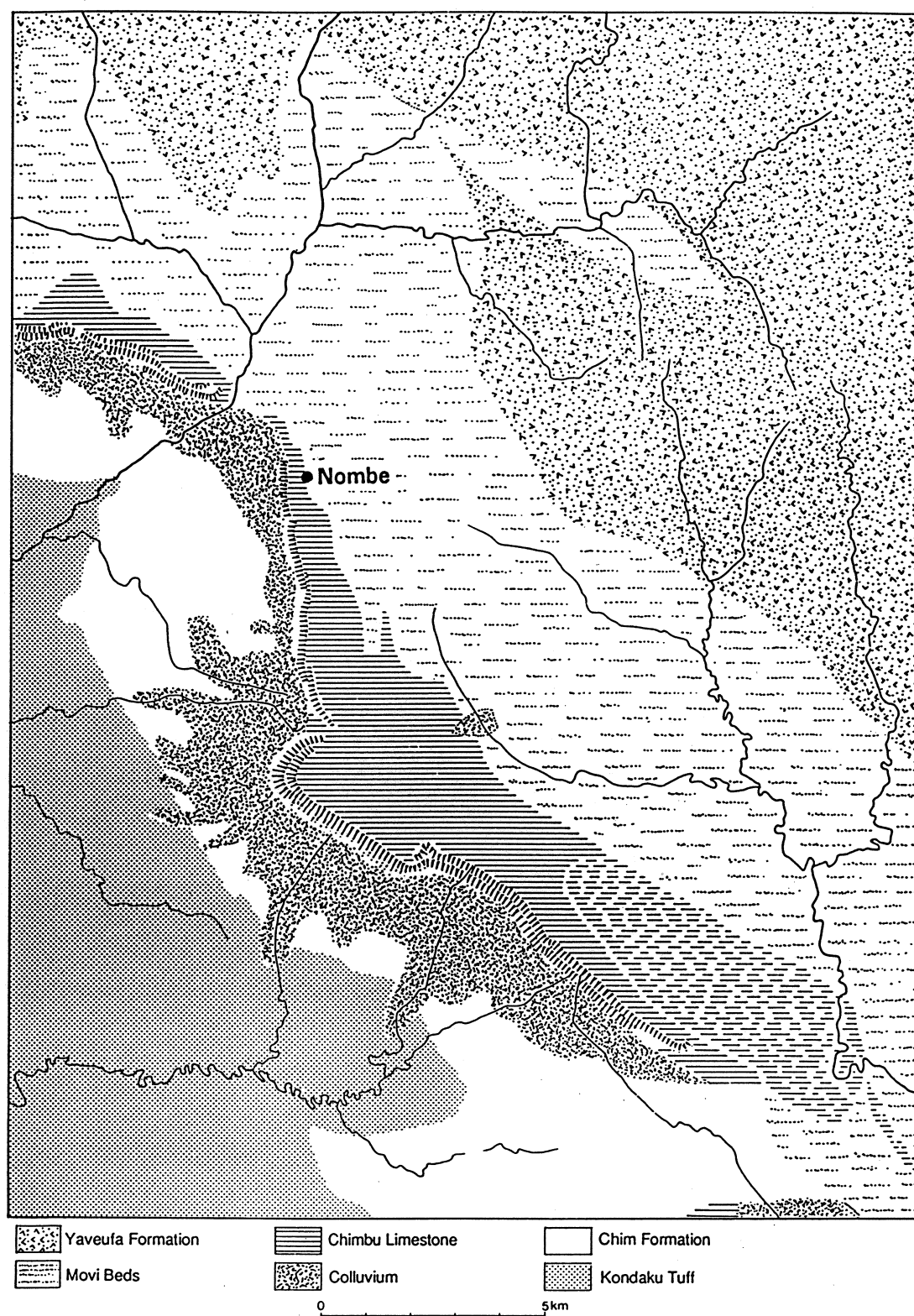
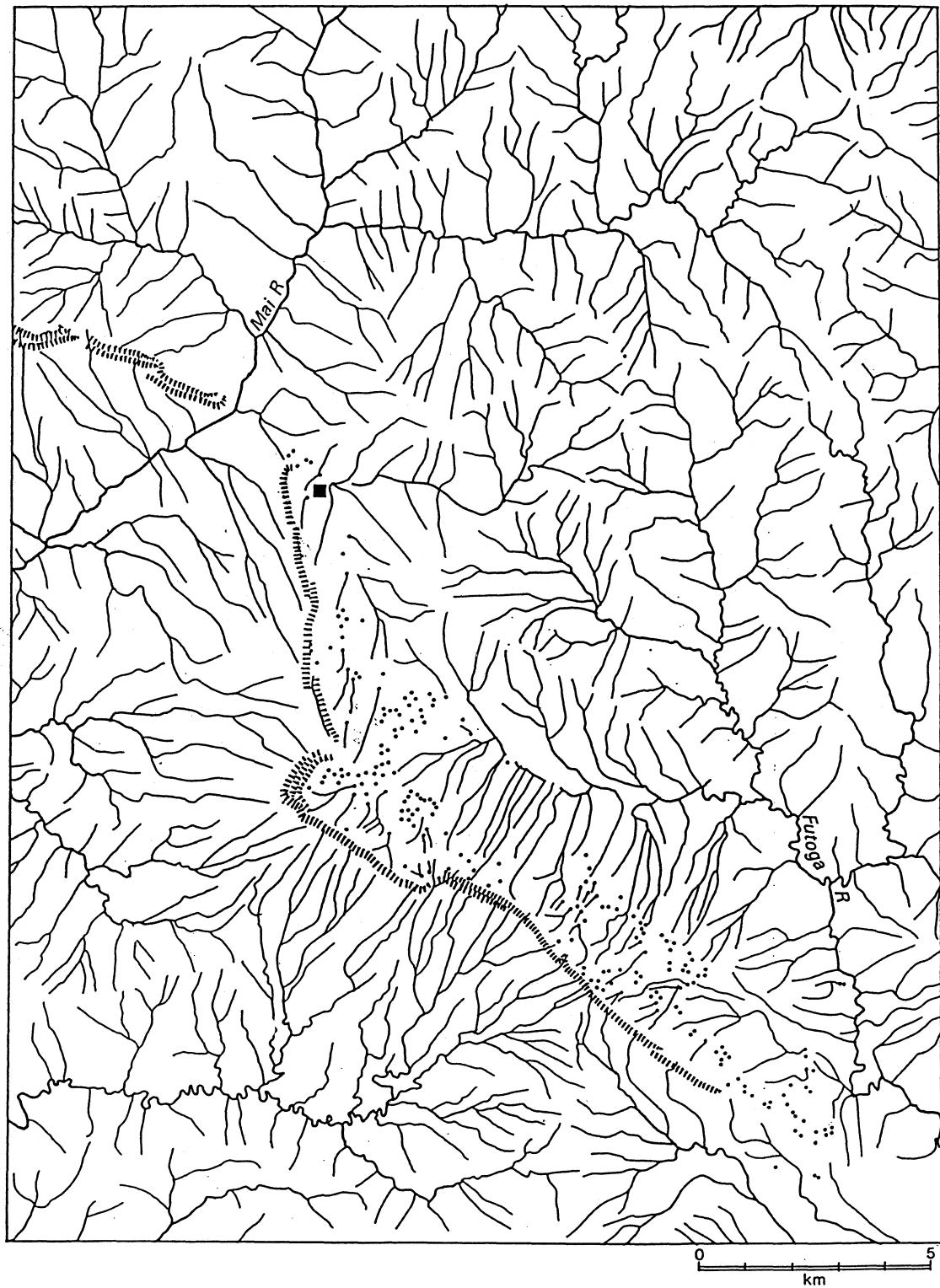


Figure 2.3 Geology of Nombe region



• Sinkhole ■ Nombe

Figure 2.4 Drainage map of Nombe region

About 10 m south of Nombe rockshelter is a cave, High Cave (Figure 2.5), with an entrance about 3 m above the level of the path running along the foot of the cliff. This cave can be entered and there is a passage leading towards the north:

...the northern end of the passage terminated in a steep drop (10 m) cut in clay sediments, with a stream channel visible at its base. This channel is at the same level as Nombe rockshelter, and its continuation is suggested by buried stalactites and wall pockets at the rear of Nombe rockshelter (Gillieson 1982:347)

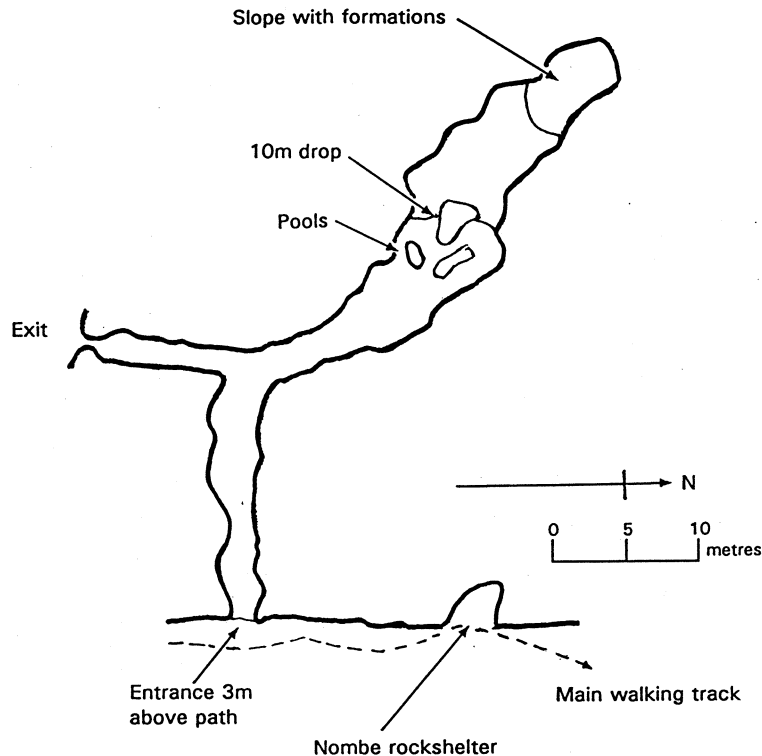


Figure 2.5 Plan of High Cave

2.1.4 Local soils

The soils of the Goroka-Mount Hagen region are classified generally as tropohumults and humitropepts (Bleeker 1983). The humitropepts are found mainly in the highlands between 1500 m and 3000 m under wet climates, on moderate to steeply sloping terrains away from volcanoes. A specific example taken from the eastern slopes of Mount Elimbari at 1980 m has been classified as a tropohumult (order: ultisols; suborder: humults; great group: tropohumults). This was previously classified as a mixture of humic brown clay and red latasols (Bleeker and Healey 1980:860). These are subgroups recently divided off from more general categories that were previously described as predominantly humic brown clays with a high humus content in the topsoil, occurring on a widespread variety of parent rocks, including igneous, metamorphic and sedimentary groups (Haantjens *et al.* 1970). The work of Pain and Blong (1979) pointed out the importance of volcanic ash in the formation of

the soils of the area, with ash coming from eruptions of Mount Karimui, Mount Au and Crater Mountain (Howlett, Hide and Young 1976:84).

2.1.5 Site of Nombe (1720 m)

The site of Nombe lies at the foot of a cliff that occurs in the karst limestone formation on the western edge of the Elimbari dip slope. The base of the cliff is now used as a pathway along the top of the cleared slope descending into the doline. This slope is at present alternately used for fenced gardens or regenerating fallow bush with secondary vegetation. Nombe lies below the eastern end of a strike-controlled ridge, running from the cliff top to the top of the Elimbari scarp ridge.

Nombe was among a group of local caves/rockshelters identified and explored by speleological enthusiasts based in Goroka in the 1950s. When Bulmer came to survey the region she identified 'Nombi' (Bulmer 1960:27) as a 'long rock shelter just west of the cave (High Cave). A number of modern type axes and axe roughouts were found on the surface, which is badly disturbed soil. Smoke stains at several points along overhang'. There is now a very small cave at the back of the site, the back of which is blocked by sediments, behind which a larger cave probably opens into the extensive local karst system: There is a reasonable area of rock shelter, frequently used now as a temporary shelter and resting place for people moving between local villages and gardens (Plate 2 and Figure 2.2). People stop at the site and frequently light a small fire, dug into the dusty top levels, to cook corn or sweet potato. The cliff in the vicinity of the site has been painted with a number of designs, using red, white and black colours. These are often in positions well above the path, difficult to reach without some form of scaffolding. There is extensive blackening of the cliff, both from smoke and also from natural staining.

2.2 METHODS EMPLOYED DURING ARCHAEOLOGICAL WORK AT SITE

The research during the 1960s at the site was outlined in Chapter 1; some detail of the methods used in these excavations, and the aims and methods of the 1979/80 fieldwork, is now necessary. Figure 2.6 presents plans of the series of excavations at Nombe while the remainder of this section discusses the techniques and methods used for each field season.

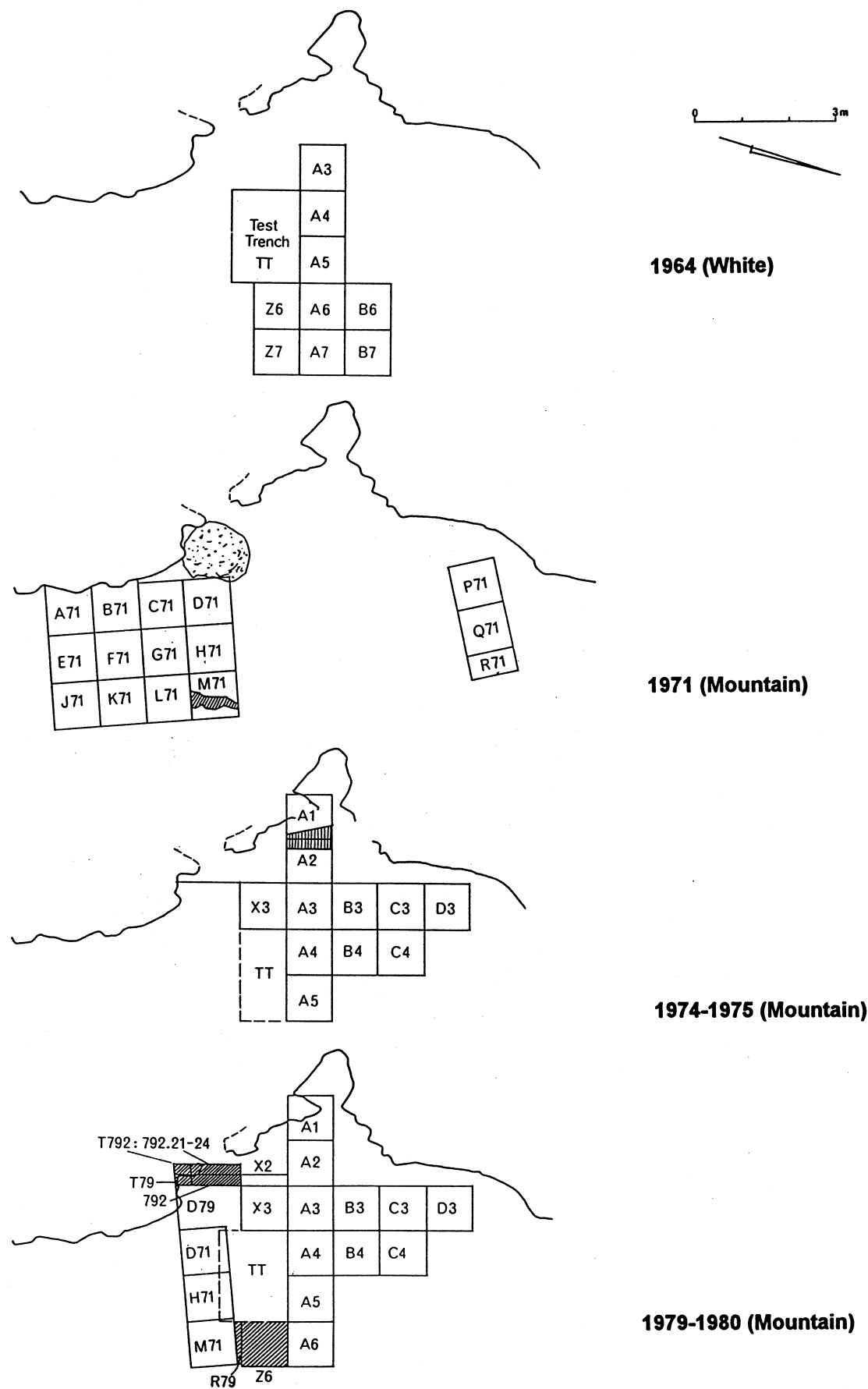


Figure 2.6 Plans of the excavations at Nombe

2.2.1 Areas excavated and techniques used from 1964 to 1975

1964 season

The area opened by White in September 1964 (White 1967) is shown in Figure 2.6. His Test Trench was large (2 m x 1.5 m) and 4.5 m³ of deposit was removed in two days. Further excavations were carried out in October 1964 immediately to the north and east of the Test Trench in metre squares designated as A3, A4, A5, A6, A7, Z6 and Z7.

All deposits were sieved through a 6.4 mm (¼") screen. Most of the squares contained a series of ashy and loamy sediments on top of a redbrown clay that appeared at varying depths below the 1964 ground surface. Squares A3-5 ^{P4} contained complex stratigraphy that included cracked flowstones and associated slipped deposits that led White to suspect that tectonic movements might have caused considerable disturbance on the site (White 1972:127). He decided to group the finds into only two categories: materials from above and in front (to the south) of the flowstones and those from below the flowstone sheets. In retrospect it was unfortunate that he encountered one of the most complex areas of the site.

1971 season

On my initial visit to the site I was concerned with an investigation into the stratigraphic problems encountered by White. A 12 m² area was chosen for excavation to the south of White's 1964 excavations (Figure 2.6). Spits of 10-20 cm were removed using local labour under the direction of myself and Ian Saem Majnep, technical assistant in the Department of Anthropology and Sociology at the University of Papua New Guinea. One metre of ashy soils and brown loams was removed from the grid ^{P10} producing very large quantities of artefactual debris, all sieved through 6.4 mm sieves without difficulty due to the dry dusty nature of the sediment. There was no sign of flowstone or other sediments. It was then decided to concentrate on the three squares (D71, H71, M71) at the north of the grid, bordering the Test Trench of White. Below the levels of the brown loams, redbrown clay deposits were located ^{P9}. These were below the bottom level of White's excavations but contained occasional artefacts and well preserved, often very large bone later identified as belonging to a series of extinct species of megafauna. Excavations were carried out by 10 cm or 20 cm spits within recognisable sedimentary units and all deposits were sieved through 6.4mm mesh, and all bone and artefactual stone were retained. However, snail and egg shell were not consistently collected during this field season. The redbrown clay was thick and very difficult to work. It had to be broken up by hand and archaeological materials were extracted in the sieve.

A further area was excavated to the north of the site (P71, Q71, R71,^{P3}) and showed little similarity with White's A3-7 profile or with the stratigraphy from the grid to the south (A71-M71). Although redbrown clay was present, often close to the surface in this area, it appeared to contain no extinct fauna except thylacine while the artefacts included chips from polished stone axes. These factors indicate that this clay is of more recent origin than the redbrown clays found in the west and south of the site, which were found at a much lower depth below the surface. Charcoal was only found in very small quantities in the upper levels of the excavation (too little for the requirements of conventional radiocarbon dating) and none at all from the redbrown clays. However, the quantity and variety of archaeological materials recovered in 1971, including extinct fauna, continued to prove the value of further investigation. In particular the nature of the association between extinct fauna and human artefacts required further evaluation.

1974 and 1975 seasons

Work continued as the project became incorporated into the fieldwork training for students taking courses in prehistory at the University of Papua New Guinea. It became necessary to reopen White's area of excavation to examine the remaining stratigraphy at first-hand, since it was so difficult to match the stratigraphies of 1964 and 1971. In 1974 a short field season was made to Nombe and the backfilling from White's Test Trench and squares A3-5 was removed. Excavation was continued in the redbrown clays underlying the base of White's excavations in these squares which were contiguous with the redbrown clay in the bottom of the squares D71, H71 and M71. New squares were opened (A1, A2 and X3). The following year these squares were completed and further squares (B3, C3 and D3) were added. Also in 1975, squares B4 and C4 were excavated to expose the top of the uppermost flowstone sheets (Figure 3.4).

As in 1971, excavation was carried out in 10-20 cm spits within recognisable sedimentary units, all deposits were sieved through 6.4 mm mesh and all materials found were kept, including snail shell. Charcoal was still very rare even in the top levels and no radiocarbon samples were submitted.

2.3 DESIGNATION OF AREAS AND EXCAVATION UNITS AT NOMBE

Had the research work at Nombe been planned and excavated as one integrated research project, the designation of all areas and excavation units would have been undertaken in accordance with the aims of the overall project. However, since the research aims and excavation requirements changed as the project evolved, these designations were added to and altered as techniques changed, resulting in a complex and often cumbersome system that requires careful explanation.

2.3.1 Designation of squares

White named the 'Test Trench' and his grid of nine squares of one metre square with an alphanumeric system (White 1967) (Figure 3.2). The 14½ squares (of one metre square) dug in 1971 were provided with separate names since, due to changes in level at the site it was difficult to be sure of the exact location of previous trenches not uncovered. Each metre square was labelled with 71 prefixed by an alphabetic character. Later squares were either incorporated into White's system (once his trenches were relocated) where suitable, or were named with the last two numbers of the year of excavation and an alphabetic character. There is one exception here as part of the Wet-sieved Strip was named 792.

In some squares where archaeological material was extremely abundant, an internal division was made in the square, usually a subdivision north to south into two areas each 1 m x 0.5 m, designated 1 (towards the west) and 2 (towards the east), so for example H71(1) and M71(2).

2.3.2 Designation of spits

The 1971 squares were dug by spits and these are designated by numbers following the square (for example, PQR71:3, H71(1):5 or M71:9). Bags of material from the same spit were designated only by date. In 1974 and 1975 squares were also dug by 10 cm or 20 cm spits but here each bag of material was given a catalogue registration number in order to record all finds with greater accuracy. These numbers can be of one, two or three digits following the spit number, so that C3:1 14 and 17 are two bags of material from the same spit of one square while within the square A2 in the second spit there are six bags of material, involving finds from a later disturbance and other individually bagged finds. Due to the complexities of the stratigraphy within the site and the fact that some squares were dug from the base of White's previous excavations and not from ground level, there is no correlation implied between spit numbers in different squares in the way of sediment matrix, depth below surface levels or datums or chronological period. Such correlations (involving stratum designations) were made at a later stage of analysis with the results of radiocarbon dating and other analytical tests to hand.

2.3.3 Designation of small wet-sieved units in 1979/80

In 1979/80 wet-sieving was employed and the designated unit of excavation involved here was a bucket or less. Spit numbering was irrelevant since far more flexible control was possible in later analysis. A strip of only 25 cm breadth was excavated by subdividing it into nine columns, four (named .11, .12, .13 and .14) within each of the squares 792 and X2 and one filling the remaining space to the south, T79. Within each column the material was removed according to changes in sediment matrix and each bucket was given a catalogue registration number of three

digits. The units therefore have the square designation, the column numbering and the registration number. An example would be 792.14 238 or X2.11 126. One hundred and thirty-six units were excavated within the Wet-sieved Strip. Some excavation units from R79 and Z6 were also wet-sieved in 1979/80 and these were designated in a similar system. R79 was subdivided into eastern, central and western areas and Z6 was divided into four strips (11-14) running from east to west. A catalogue registration number of two or three digits was added to each bag of finds recovered.

2.4 TECHNIQUES OF 1979-80 EXCAVATIONS AT NOMBE

By 1979 the project had become part of a doctoral thesis and the aims of the excavation had altered. There existed a substantial quantity of excavated materials and stratigraphic information that had to be taken into account from previous excavation during interpretation. There were still considerable problems with the stratigraphy, especially in the necessity to test whether deposits that appeared visually similar from separate areas of the site were, in fact, of similar origin and if so, whether they were deposited at the same period of time. There were also problems in that previous excavation had been by fairly gross units, of at least 10 cm depth over a metre square and in many cases greater in depth. It was necessary, in order to be able to analyse some rather elusive stratigraphic units in further detail, to proceed by smaller archaeological units that could be amalgamated in a more flexible fashion. Wet-sieving was desirable to recover very small bone, charcoal and plant remains. There was also an urgent need for chronological pointers to the development of the site and, since charcoal had proved so rare on the site, the dating of other materials had to be considered.

It was in response to these specific requirements that further investigation of Nombe was carried out from November 1979 to February 1980. In order to test the validity of the stratigraphy as it was perceived in 1979 (Section 3.1.1), David Gillieson, was invited to visit the site for two weeks in mid-November 1979 to undertake sampling for sediment analysis of the deposits at Nombe. In order that Gillieson and I could examine and sample from as much of the previously excavated areas as possible, the backfilling of the squares in central areas of the site was removed.

Following Gillieson's visit to the site, work on the excavation of the Wet-sieved Strip began. This site was chosen since it was the only area of the site that contained all the major stratigraphical deposits without deposits that had proved either archaeologically sterile (such as the tephra) or extremely difficult to excavate (such as the flowstones and consolidated deposits). Since the chosen area lay behind the Consolidated Block D79/X3 ^{P1}, it was necessary to remove this prior to the wet-sieving. Due to its hardness and in view of limited time, rather crude methods had to be used (mainly hammer and chisel) to break it down. Where feasible, archaeological

material was removed from the consolidated matrix but this was not always possible. Some very large pieces were taken back to Canberra intact but others had to be left due to the expense of transport.

Once the Consolidated Block of D79 and the underlying redbrown clays had been removed, excavation began on the narrow strip immediately behind it, subsequently referred to as the Wet-sieved Strip (Figure 3.2). This was divided into nine columns as described in Section 2.3.3 and was excavated by numbered units of one sediment matrix (no more deposit than would fit into one bucket). The sediment in each excavation unit was fully described and its dimensions noted. One hundred and thirty-six units were processed, each bucketful was weighed and the weight of the natural stone occurring within that bucket was recorded before being discarded. By this means it was possible to calculate the bulk density of each unit; but, since the weighing was done at the site immediately after removal from the ground, the results vary from those obtained from laboratory air-dried samples.

The contents of each bucket were wet-sieved by adding water from the local stream with 5 ml of detergent and passing through a series of sieves, the last of which had a mesh of 1 mm. The top deposits dissolved well and materials could be easily removed, but the process was much more difficult in the clay deposits and in some cases hand-sorting from the sieves had to be used to aid the lengthy process of washing the clay through the mesh. It was not possible to retain every minute chip of eggshell or bone, especially in the levels where they were very abundant since this would have involved the retention of the entire volume of sediment for all Stratum B units. However, one sample was retained containing the entire complement of tiny shell and bone fragments from the Stratum B deposits, where the highest density of artefacts with eggshell was recorded. It was possible to excavate and process up to 10 buckets per day, using two full time local assistants and many part-time helpers. The final deposits left in the 1 mm sieve were emptied on to absorbent paper, wrapped, carefully labelled and left hanging to dry in the air. Deposits remaining on the surface of the liquid were scooped up and dried out in the same way.

In order to provide a set of comparative data from an area of the site further to the east, near the drip line, it was decided to wet-sieve the deposits of a small strip labelled R79 that theoretically still remained between M71 and Z6 (Figure 3.2). However, when excavation began here, it was found that due to the erosion of the edges of previous trenches, there were no original deposits left in the strip for the first 20 cm - 30 cm below the existing ground level. Basal deposits in square Z6, below the depth at which White had ceased excavation in 1964, were also excavated. Wet-sieving was only applied to about half the deposits excavated from Z6 and R79 during 1979-1980 due to lack of time. Apart from some small excavations to determine the limits of a heavy brown clay within the basal levels of squares D71, X3 and A5 and the removal

of four surface units by wet-sieving from the next 25 cm strip within square 792, no further excavations were carried out.

All finds from each bucket excavated were amalgamated in one labelled bag for storage and later flown to Canberra for analysis.

Chapter 3

Stratigraphy and a Model of Sediment Deposition at Nombe

3.1 STRATIGRAPHY AT NOMBE

Crucial to the Nombe research was the interpretation and dating of every area of the site. It is impossible to analyse the contents of any sediment with any confidence without understanding that sediment's precise stratigraphic and chronological position in the site.

The lack of charcoal in most deposits was, by 1979, a major impediment to the production of a satisfactory chronological framework. A new program of dating was therefore initiated following discussions with the Australian National University Radiocarbon Laboratory staff. This program was to include the dating of samples from materials known to exist in the site in order to produce a set of coherent dates. These materials were:

Charcoal. At this stage charcoal had only been documented in small amounts from surface sediments. It was planned to obtain larger charcoal samples through wet-sieving of lower deposits.

Bone. Bone is readily available throughout the site. However, the declining collagen content with increasing age would reduce the ability to date by ^{14}C methods.

Snail shell. Snail shells are a major component of the older redbrown clays which include few other suitable dating materials.

Flowstone and calcite-capped cemented clay. Flowstones occur in the middle stratigraphic level and offered an opportunity for dating. A series of cemented clay blocks capped with thin calcite layers occur at the base of the site and are also suitable for radiocarbon dating.

The results of this complex program of dating had to be integrated with an interpretation of all sediments present. The site's central areas revealed four distinct main strata (Plate 5) but the peripheral areas were much more difficult to analyse. This chapter begins with a summary of the perceived strata in 1979 and then discusses all sediments in more detail. The manner in which different analyses were

integrated into the emerging understanding of the site is discussed and a finally detailed model of site development over 30,000 years is presented.

3.1.1 Perceived stratigraphy (Profiles 1-11)

Stratum A - Top sediments, usually loose dusty soils resolving to firmer darker loams.

Stratum B - Dark brown loam, similar to Stratum A but with a noticeable increase in the quantity of human artefacts and especially in animal bone, a high proportion of which is burnt and broken.

Stratum C - This stratum includes several sediments including flowstones, tephra and a reddish brown sediment with a higher proportion of clay than in higher sediments.

Stratum D - Various types of clay: mainly redbrown heavy clay but below which is textured ginger clay and a basal brown, even stickier, heavier clay.

However, there were areas of the site where this basic stratigraphy was not apparent. The analysis of these areas therefore depended on:

- ☐ the radiocarbon dating of sediments;
- ☐ archaeological data from the sediments; and
- ☐ sediment analysis undertaken by Gillieson.

An example of such an area occurs at the base of C3 and D3 ^{P2} where several different sediments underlie conventional Stratum A and B type sediments. It was not clear whether they should be Stratum B, C or even D sediments. Some deposits of comparable sedimentary type and origin have been laid down at different times and therefore may contain quite different archaeological materials. Such deposits are of course classified according to the time of deposition not the sedimentary similarities of the deposit. For example, redbrown clays normally belong to Stratum D but in some areas of the site deposits of redbrown clay have been classified (after deliberation) as belonging to Stratum B (as in Profiles 2 and 10).

3.1.2 Mixing of deposits

During analysis it was realised that some of the sediments had been mixed and that in specific areas stratigraphy was inverted, probably due to human activity towards the end of the Pleistocene. All sedimentary units were carefully examined for evidence of such disturbance and, if any hint of such mixing was detected, an "X" was included after the unit designation and such units were removed from further analysis.

3.2 DETAILED DESCRIPTION OF SEDIMENTS IN EACH STRATUM

The following sections describe the perceived stratigraphy; each stratum consists of a number of sediment types, each with an individual numerical designation. Colour references are from the Munsell Standard Soil Color Charts, 1975.

3.2.1 Stratum A: the top deposits

These generally consist of fine dusty or ashy soils, varying from cream (10YR 6/2), through grey brown (5YR 3/3, 10YR 4/4) to dark brown (5YR 2/2) or almost black (5YR 1/7).

Stratum A contains three subgroups:

- A1:** grey brown dusty soil;
- A2:** similar but with an greatly increased ash content; and
- A3:** darker, more humic and often wetter surface deposits.

Profiles 5, 8 and 10 show the variations within Stratum A. Stratum A sediments are all extremely light and are very easily disturbed by human, pig and dog activity. This has created a great deal of change in the ground level in relation to the limestone cliff face. Between the first surface - level recording in October 1964 and the end of the final field season in February 1980 there was a drop of as much as 50 cm in some areas **P11**. This was due to the normal, frequent human movement on the site as well as the archaeological excavation and settling of the back-filled trenches. The depth of Stratum A varies from under 10 cm **P5,7,8** to over 100 cm in the eastern (front) part of the site **P9,10**. In one area, in the south of D79 **P1**, the brown sediments of Stratum A (which are here very deep and lie within the D79 Channel), are overlain by blacker, wetter, surface deposits in the Drainage Crack that also belong to Stratum A, but are of a more recent date.

Stratum A deposits contain artefacts, a little scattered charcoal in protected places, a few large blocks of limestone and occasional cooking stones.

3.2.2 Stratum B: the bone stratum

The interface between Stratum A and Stratum B is extremely marked near the western area (back) of the site and three types of B strata are evident:

- B4:** the sediment matrix, is normally brown loam (5YR 3/2) and is similar to that at the base of Stratum A. There is a visible increase in the density of archaeological material, especially in the quantity of bone. Profile 5 shows this clearly, where the quantity of burnt and fragmented bone increases suddenly to produce a noticeable stratigraphic change.

B2: in the area of A3/B3 ^{P4} where the brown loam changes to yellow grey ashy sediment (2.5Y 5/2) this is designated as B2, similar to the matrix of the overlying Stratum A deposits in the same area and again differentiated by a noticeable increase in artefact density.

B5X: in squares A1 and A2 at the base of the brown loam where there is a red or brownish gritty layer it is labelled Stratum B5X. Profile 4 shows that this layer appears connected with the local disturbance caused by the digging of the A1/2 Trench.

However, in squares C3 and D3, Stratum B cannot readily be differentiated from Stratum A because of the similar density of bone fragments in both strata. Three types of B strata have been designated in this area:

B9: is a brown loam flecked with red particles, containing artefacts, lying underneath the top grey brown dusty soil of Stratum A ^{P1,2}.

B6: is a redbrown clayey sediment (also flecked with red) lying under B9, in D3 and the northern area of C3. This melds at the base of those squares into another redbrown clay, also designated B6. This continues into PQR71 where it thickens considerably and rises to within 50 cm of the present ground surface in R71 ^{P3}. These are much younger than the redbrown clays to the south and west of the site.

B8: is a basal dark red clay (2.5YR 2/4) found in C3. This appears to be older than the redbrown clay at the base of D3.

In the 1979/80 excavations of the basal levels of squares Z6 and R79 it was found that the top redbrown clays immediately under White's 1964 excavation base overlay a band of very dark, rather wet loamy deposits (B7) at the eastern side of Z6. Both this loam and the overlying clay contained high proportions of artefacts and bone and show no evidence of Pleistocene fauna. Both deposits have been designated as Stratum B and are presumed to be Holocene in date. It is likely that the redbrown clay that White found at the base of his excavations in the eastern squares (A7-8, B7-8 and Z7-8) belongs to the same recent redbrown clay rather than to the Stratum D Pleistocene redbrown clay that occurs farther west.

B7: is a dark wet loam lying directly on redbrown clays which, from their archaeological content, are designated as Stratum D Pleistocene clays.

B3: is a redbrown clay lying over B7 and under stratum B4 deposits.

There is an area of stratigraphic complexity in Stratum B in the southern face of squares D79 and D71 ^{P9}. At this point Stratum B appears to represent three distinct periods of deposition, each overlaid on the other, sloping downwards from west to east.

In the eastern areas of the site ^{P4}, erosion (presumably caused by the drip line and the natural eastward fall of deposits towards the Lombila Doline slopes) has truncated

the Stratum B4 sediments along with the underlying Stratum C deposits which have been replaced with more recent Stratum A deposits. However, in Profile 9 (only three metres to the south) the Stratum B4 sediments continue beyond the drip line in M71, although the underlying redbrown clay drops in level, which may indicate earlier dripline erosion.

Artefacts are especially prominent in Stratum B in both H71 and M71 where the matrix is brown loamy sediment (5YR 3/2).

Pieces of tephra-like material are common in this stratum, both in the D79-M71 trench ^{P9,10}, and also within the Consolidated Block in D79/X3^{P6}.

3.2.3 Stratum C: various deposits

These deposits occur beneath the Stratum B deposits and above the underlying clays of Stratum D. Their sedimentary origin is mixed and not all elements always occur together. Although they therefore form a rather unsatisfactory stratum, it is necessary to isolate them as an independent stratum between D and B, since together they represent an important period of the site's sedimentary history.

There are three elements present in Stratum C: flowstone sheets, tephra-like blocks and redbrown sediments ^{P1,4} (Plate 4). It is the flowstones and tephra-like blocks that are so prominent in the stratigraphy as uncovered by White in squares A5-8 in 1964. Nevertheless, both these elements occur within other strata and are not exclusive to Stratum C; flowstone is found attached to the roof ^{P7}, high in the Consolidated Block D79/X3 ^{P9} and in the paper-thin traces occurring towards the top of the redbrown clays in A4/A5 ^{P4}. There are pieces of this tephra-like deposit in the basal clays ^{P6,7}, as well as within Stratum B ^{P6,9,10} and at the base of Stratum B levels in the Wet-sieved Strip ^{P8}, where a band of distinct blue/grey (5PB 5/1) sandy pellets lies at the top of Stratum C, immediately under the bottom of the thick bone levels of Stratum B. No tephra-like materials occur in the northern squares (C3-PQR71) or in the squares south of Profile 9 (A71-C71, E71-G71 and J71-L71).

The thickness of these Stratum C flowstone sheets varies from under 1 cm to over 10 cm. The sheets are commonly brilliant white and crystalline, but some are creamier (2.5Y 8/2). Like the flowstone in the centre of X3 ^{P6}, they sometimes have mixed deposits adhering to their underside containing loam, charcoal flecks and artefacts. They can occur lying almost horizontally ^{P4} but more commonly with a pronounced south-eastwards slope, presumably resulting from the ground surface slope on which they were formed. It is established that flowstones can form on considerable slopes. The cracks (Plate 9) that are now evident in the flowstone sheets and tephra-like blocks which caused White to exercise such caution in artefact analysis (White

1967:127), could have developed as the result of purely local factors, such as increased solutional enlargement of underlying bedrock joints (Gillieson 1982:347).

The tephra-like blocks that are sandwiched between flowstone sheets 2 and 3 in A3, A4, and A5 ^{P1,4} are generally greenish-grey in colour (10Y 3/2, 10Y 5/1). The basal part of these blocks is clearly laminated with a gritty sandy texture. The upper part shows a more vesicular structure with less clear laminations (Plate 10). Under the bottom of the consolidated blocks in the D79/X3 area, there are pieces of similar tephra-like, greenish-grey, sandy materials ^{P1,11} lying directly on top of the basal redbrown clays, although they are not continuous throughout those squares ^{P6}.

The sediment matrix in which the Stratum C flowstones and large tephra-like blocks occur comprises redbrown sediments (5YR 4/4 and 4/6), designated C8, with a high apparent clay content, but drier and much less plastic than the underlying redbrown clays. They are described by Gillieson (1982:352) as cemented redbrown clay with a coarse granular texture. They often contain small chunks or larger blocks of limestone, as well as occasional artefacts and bones. These redbrown sediments occur as a thin capping to the redbrown clays above the line of Flowstone 3 in A3 ^{P4} and to the south of the major flowstone and tephra-like block area in A3 and X3 ^{P1}. They do not occur to the west of the A1/2 Trench ^{P4,5} or in the D71-M71 squares ^{P9}.

In the centre and west of the Consolidated Block D79/X3 ^{P6}, there is a thin level of redbrown sediment running over the basal redbrown clays and containing tephra-like pieces. Further west again in the Wet-sieved Strip ^{P7,8} there are thicker deposits of redbrown sediment overlying the redbrown clays, containing artefacts and snails. These sediments lie between the base of Stratum B and the top of the Stratum D redbrown clays and have been designated as Stratum C deposits. In Profile 8 (only 25 cm to the west), these redbrown sediments lie between a thick level of large snails and a thin but easily visible scattering of lumps of blue-grey tephra-like material which underlies the thick Stratum B deposits.

3.2.4 Stratum D: redbrown clays

The redbrown clays occur throughout the basal levels of the site. They are clearly identifiable but are present in six distinct subgroups:

D4:thick, heavy, brown, plastic clay designated D4 (5YR 3/6). This occurs at the base of the excavated profiles towards the west (back) of the shelter ^{P4,5,6,7,8}.

This clay always slopes strongly to the south-east. In the eastern areas of the site this brown, plastic clay cannot be recognised as an independent unit.

D3:basal redbrown clays (5YR 4/8) designated as D3 in D71-M71, R79 and Z6 and A6 ^{P9,10,11}. They are equally as heavy and plastic in texture as the D4 clays but occur very rarely within the excavations.

D2: lighter textured, drier, ginger-coloured redbrown clay (7.5YR 5/6) designated as D2. This south-easterly sloping band lies above the heavy, plastic, brown clay. In the west of the site, there is another area of D2 clay **P1,4,6,7&8**.

D1/D5: bright redbrown clay (5YR 4/6) which accounts for most of the remaining clay. This is designated as D1 when free of limestone fragments and D5 when it contains considerable amounts of limestone pieces. D1/D5 is found overlying all previous D clay groups and in some areas is found alone. It is frequently of considerable thickness and in H71 reaches 70 cm in depth over the basal 'floor' of cemented clay blocks **P9**.

The Munsell Soil Color Charts are extremely inadequate on the redbrown range of colours found in Strata C and D at Nombe. Gillieson classifies Stratum D as yellowish brown, following the notation of colours such as 10YR 5/6 and 5/8, but I found the tones more correctly described as redbrown and cover varieties including 7.5YR 5/8 and 5YR 4/6.

3.2.5 Other components of the stratigraphy and site

In the lower strata, C and D, there are many large land snails, often found in clusters. These also occur immediately under Stratum B in some places at the west of the site (for example in squares A1, A2, B3 and the Wet-sieved Strip).

There are also a number of very large, presumably fallen, limestone blocks in the shelter, usually resting on and in the basal redbrown clays (Plate 8). Some were too large to be removed or continued under the baulks; these included those shown in White's Test Trench **P11**, A6**P4**, C3/D3 and PQR71 **P1,2,3** and Z6 **P10**. Others, of a smaller overall size and in more convenient areas, were removed during excavation. In some cases, the top of these blocks has been altered by continuing accretion of calcium carbonate and other materials, so that there are now artefacts and snails attached **P2,11** (Plate 13). In other places the limestone has altered in appearance and composition, so that patches of soft yellow limestone sit over a base of hard grey limestone **P1,2**.

In areas of active roof drips, existing deposits have been cemented together into blocks by calcium carbonate accretion **P1,7,9**. These blocks are referred to as consolidated or brecciated blocks and, in the case of one extreme example of this process, as the Consolidated Block D79/X3P1. Here, blocks of consolidated deposits have gradually built up over the redbrown clays and tephra-like sediments until a solid block of deposits has actually become cemented to the limestone roof. When this was removed, several active roof drips continued to emerge from the remaining roof boss in the 1979/80 wet season.

In the base of the site in squares D71-M71 there is a 'floor' of flat blocks which appear to be made of cemented clay, capped frequently by a thin layer of calcite (Gillieson 1982:360) ^{P9,10,11}.

The importance of water flow in the site formation can be seen in the number of roof pendants and of large and still active water drips that occur during the wet season ^{P4}.

In squares A1 and A2 there is a very distinct man-made trench dug across the cave, increasing in size and depth towards the north ^{P4,5}. This was only located within Pleistocene sediments in the archaeological squares A1 and A2 and is referred to as the A1/2 Trench.

3.3 PROGRAM OF SEDIMENT ANALYSIS

Although many elements of this stratigraphy appeared well defined, sediment analysis was essential to determine whether the four strata had originated from similar sedimentary processes. Without this there could be little meaningful analysis of the archaeological materials.

3.3.1 Sediment analysis

During his Nombe visit, Gillieson took samples from the exposed profiles following discussions on the perceived stratigraphy as set out in the previous sections. He analysed the 41 samples including some supplied from excavations before and after his departure; their positions are shown in Profiles 1-11. His results (Gillieson 1982: 373-423) largely verified the perceived stratigraphic groups (strata A-D) and provided information on the sedimentary processes that formed the deposits. His analysis produced four groupings of samples which he named A-D. In order to prevent confusion with the already existing Strata designations A-D, I have altered his group names as follows: Group A becomes Group W, Group B becomes Group X, Group C becomes Group Y and Group D becomes Group Z.

Group W. All six samples taken from Stratum A (sample numbers 44, 50, 54, 55, 75/68 and 75/69) and three taken from Stratum B (sample numbers 33, 34 and 21) group together in the sediment analysis to form Group W. The stratigraphic position of these samples is shown on Profiles 1, 3, 4 and 6. They represent many of the variations occurring within the strata as described in Section 3.2. They contain an extremely poorly sorted group of particles that spread over the sands, silts and clays, with a low content of fine clay particles. Since the perceived differences between Stratum A and B lie in the increase in archaeological matter within similar sedimentary matrices, this result is as expected. The sedimentary matrix is drawn from a large number of sources, including wind-blown soils from gardens, fire ash,

slopewash from heavy rains, cliff run-off and human rubbish from occupation and activity at the site.

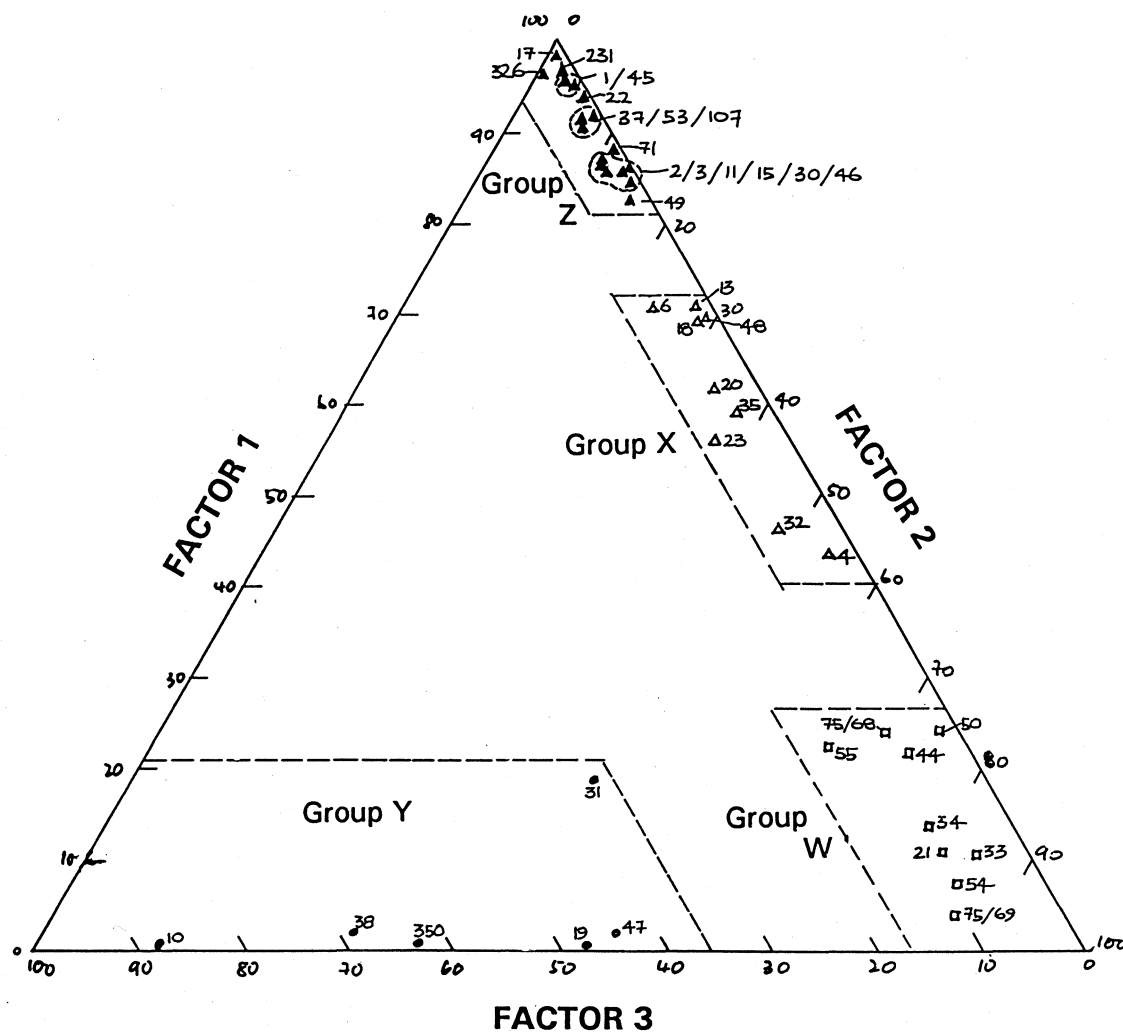


Figure 3.1 Plot of normalised varimax factor scores for Nombe sediments
Source: Modified from Gillieson (1982:Figure 113)

Group Z. One major objective was to test the sedimentary similarity within the varying types and occurrences of the redbrown clay of Stratum D. Accordingly, a large number of samples was taken from this stratum throughout the site and covering all varieties of texture and colour. Seventeen of these samples formed one sedimentary group, Group Z. The sample numbers are 53, 1, 2, 3, 11, 15, 22, 107, 37, 17, 75/71, 45, 46, 49, 30, 231 and 326 in Stratum D *P1,2,4,5,6,7,9,11*. Figure 3.1 shows the close final grouping of the samples as determined by particle analysis. Although there are minor variations within the particle size patterns of the 17 samples, they are extremely

closely correlated which suggests that the variations within the redbrown clays were due to minor differences of source material or later weathering. Gillieson (1982:390) notes that the textures of this group all fall within the envelope of the slopewash deposits from another cave site, Selminum Tem, in the Western Province of Papua New Guinea, where there is still a stream flowing through the site, and therefore suggests that the samples in Group Z originated from deposition of fine clays by an active spring and stream at Nombe.

Group Y. Six further samples (sample numbers 10, 31, 38, 350, 47 and 19) all contain a considerable proportion of fine sand and form a separate sedimentary group, Group Y, whose sediments were generally poorly sorted. Although these samples come from different stratigraphic positions within Strata B and C ^{P1,2,4,6,9}, they are all from areas where tephra-like materials were located. The fairly wide variation in the particle size patterns of these samples (Gillieson 1982:387) indicates not only differences within the composition of the samples (for example, there is a wide variation in colour present) but also the presence of other sediments within some samples. I suggest that this group represents a number of separate tephra occurrences, laid down at different periods of time and in most cases mixed with components from their surrounding matrices.

Group X. The remaining samples are the least satisfactory in terms of verifying the perceived stratigraphy and do not correlate well with any group of stratigraphic features. There are nine samples: three from Stratum B (4, 32 and 48), two from the redbrown sediments of Stratum C (6, 20), one (35) from a block of consolidated materials under a flowstone sheet in X3, one from the top of the redbrown clays (13), one from the dry, ginger variety of redbrown clay (18) and the last from the basal filling of the A1/2 Trench (23). Their stratigraphic positions can be seen on Profiles 1, 2, 4, 6 and 9. Figure 3.1 shows how this group (Group X) sits between the ranges of Group W (with little fine clay) and Group Z (with a predominance of fine clays). However, many of these samples come from unique stratigraphic positions and may well represent examples of mixing of materials from various situations, for example samples 4, 48, 35, 20, 23. I suspect that if further samples were collected and analysed from other unique situations where mixing could have occurred, results might spread even farther along the range from Group W to Group Z, rather than produce a tighter grouping of Group X.

3.3.2 Summary of sediment groups in relation to perceived strata

Sediment group W shows high correlation with Strata A and B. These are archaeologically distinct but geomorphologically uniform.

Sediment group Z shows high correlation with Stratum D.

Sediment group Y shows high correlation with tephras from the site.

Sediment group X contains a subgroup of samples from Stratum C redbrown sediments, together with some samples from the top of the redbrown clays, as well as a number of samples that are the result of physical mixing of deposits from Strata B, C and D.

Gillieson (1982b) used scanning electron microscopy to test some hypotheses as to the origin of some deposits at Nombe. His work confirmed that the redbrown clays were fluvial in origin, the quartz crystals displaying the typical rolled rounded features caused during water movement. It was obvious that firing had played an important role in the formation of deposits in Stratum A and B and this was again confirmed by the shape and cracking of the quartz particles in those strata.

3.4 DATING

Detailed scrutiny of the sediments, backed by a program of sediment analysis, provided a comprehensive understanding of the processes which, over a long period, formed the sediments now existing at Nombe. But without evidence of the chronology of these processes it is not possible to produce a meaningful model of site development.

The ambitious dating program, which included many controversial materials not systematically used at that time for archaeological dating, produced the evidence necessary for the chronological framework.

Through wet-sieving techniques it was planned to recover sufficient charcoal for ^{14}C dating during the 1979/80 fieldwork season. However, adequate samples were only found in Stratum A. Small quantities occurred in other strata, but never in large enough amounts for conventional ^{14}C dating techniques.

On return from the field, samples of several other datable materials were therefore prepared, including bone, snail shell and calcite speleothems. This last category was also suitable for uranium/thorium dating and Gillieson submitted three Nombe samples to Professor D. Forde, McMaster University, Canada.

All dates used in this thesis are presented as a range of one standard deviation on each side of the mean since this provides a more accurate representation of the age of each sample than quoting the date as presented by the laboratory. The ^{14}C results are reported in Appendix B as "Conventional Ages" (Stuiver and Polach 1977), and any environmental correction factors can be considered separately, since these values are

laboratory measurements and are not subject to any change. Table 3.1 presents all dates from the site.

Table 3.1 ^{14}C dates from Nombe sediments and incorporated materials as originally laid down (see note)

Stratum	Range Age BP	ANU No.	Correction
Stratum D2	33 050 – 31 150	ANU 2566	
	30 100 – 29 100	ANU 2565	
Stratum D1/5	25 200 – 24 400	ANU 2578	Corrected
Stratum C	14 800 – 14 500	ANU 2580	Corrected
	13 650 – 12 650	ANU 3683	
	12 000 – 11 700	ANU 2581	Corrected
	11 810 – 11 490	ANU 3681	
	11 590 – 11 210	ANU 2569	
	10 150 – 10 350	ANU 2579	
	10 150 – 10 350	ANU 2576	
Stratum B	9 930 – 9 370	ANU 3686	
	9 160 – 7 480	ANU 3687	
	6 860 – 6 620	ANU 3688	
	6 470 – 6 290	ANU 3075	
	5 990 – 5 630	ANU 3074	
	5 980 – 5 760	ANU 3076	
	5 450 – 5 230	ANU 3684	
	5 310 – 4 870	ANU 3689	
Stratum A	3 730 – 3 110	ANU 2570	
	980 – 820	ANU 3685	Charcoal insoluble
	100.4 ± 09%M	ANU 3073	

Note: This list only includes dates from materials within sediments interpreted as 'in situ'. It does not include dates from samples interpreted as coming from material thrown up by human trenching in the Pleistocene clays or from samples using snail from several squares.

3.4.1 Interpretation of laboratory dates

The use of varied materials in the dating process required not only great care and difficulty in dating each sample but extreme caution in the interpretation of the laboratory dates. The $\delta^{13}\text{C}$ results for the ^{14}C samples (Table 3.1) provide information on:

- ☐ mode of deposition (flowstones and calcite samples),
- ☐ living environment (snail shells), and
- ☐ possible contamination and diet (bones).

This information can provide clues as to whether the samples are contaminated and whether the same or different correction factors can be used for samples of the same type. In the case of the bone and snail samples these figures conform to the range expected (Stuiver and Polach 1977:358), so that little correction should be necessary.

Bone samples

The $\delta^{13}\text{C}$ figures from the bone samples (Table 3.2) suggest that the bone has not been subjected to long periods of saturation by water, but rather the process has been one of frequent soaking and drying. This accords with the interpretation of the post-Pleistocene sedimentary history of the site from which all but one of the bone samples derives. Some contamination is present from acid insoluble soil; for example, in the case of ANU 3076 it was not possible to date a collagen fraction due to the presence of acid insoluble residue. Where bone dates are quoted, the oldest result of each pair has been used, after consultation with John Head of the Australian National University Radiocarbon Laboratory. The results obtained for ANU 3685 (charcoal) indicate the possible presence of younger humic acids in the site. Hence, if the collagen is contaminated by humic material, it would provide a falsely young age. Similarly there is no evidence of mobility of old carbonate through the site. Because of this, any carbonate contamination of the bone apatite would produce a falsely young age. There is every indication that the apatite is contaminated in some cases and the collagen is contaminated in others. In every case, even the oldest result should be considered as a minimum age (i.e. both fractions may be contaminated). The table below shows that the $\delta^{13}\text{C}$ figures for the bone samples are furthest apart in cases where the collagen fraction is younger and therefore the apatite result is likely to be more reliable. In cases where the difference between the $\delta^{13}\text{C}$ results is smaller, the collagen fraction is older and therefore has been used. In the case of ANU 3687, where the $\delta^{13}\text{C}$ results differ greatly, the date ranges overlap and the widest range has been chosen.

Table 3.2 $\delta^{13}\text{C}$ values for ^{14}C bone samples

ANU number	$\delta^{13}\text{C}$ Apatite ‰	$\delta^{13}\text{C}$ Collagen ‰	Difference	Apatite range	Collagen range
3074	-11.1*	-23.2	12.1	5 630 – 5 990	4 920 – 5 140
3075	-11.1	-21.8*	10.7	5 790 – 6 010	6 290 – 6 470
3076	-11.4	na	-	5 760 – 5 980	na
3683	-10.3*	-24.0	13.7	12 650 – 13 650	5 470 – 6 950
3684	-14.2	-23.4*	9.2	2 940 – 3 500	5 230 – 5 450
3686	-14.9	-23.8*	9.8	8 800 – 9 200	9 370 – 9 930
3687	-9.9*	-23.5*	13.6	7 720 – 8 420	7 480 – 9 160
3688	-14.8	-23.4*	8.6	5 670 – 6 090	6 620 – 6 860
3689	-12.5	-23.5*	11.0	3 040 – 3 480	4 870 – 5 310

Notes: na Not available for reasons stated in text.

* = most reliable date

Snail samples

Verification of the reliability of the results is particularly necessary in the case of the snail samples since, in three cases (ANU 2564 and 3076, ANU 3682 and 3683 and ANU 3681 and 3687), samples of snail shell and bone from the same archaeological unit have widely differing results, raising doubt as to the reliability of some of the snail shell dates. However, the $\delta^{13}\text{C}$ results (Table 3.3) are of the expected order and there seems no likelihood of major correction factors having to be applied to the results. The $\delta^{13}\text{C}$ results from the snail samples show two groupings: ANU 2562 and 3329 were apparently formed in equilibrium with the atmosphere, but the rest of the samples show a higher organic composition. ANU 2562 and 3329 are both from samples known to contain snail shell that may be of very recent date, found on or immediately below the modern surface, whereas the rest are from sealed archaeological deposits. This result is thus not unexpected.

Table 3.3 Radiocarbon dating from snail samples at Nombe

Lab No	Position	Date Age BP	Range Age BP	$\delta^{13}\text{C}$ ‰
ANU 2562	Mixed	6 360 ± 210	6 150 – 6 570	-7.9 ± 0.4
ANU 2563	Mixed	16 500 ± 280	16 220 – 16 780	-12.9 ± 0.4
ANU 2564	A1:4 21,24	26 000 ± 1 050	24 950 – 27 050	-8.6 ± 0.4
ANU 2565	X3:6 1	29 600 ± 500	29 100 – 30 100	-11.1 ± 0.4
ANU 2566	A4:3 3	32 100 ± 590	30 050 – 31 150	-12.3 ± 0.4
ANU 3681	C3:4 40,46	11 650 ± 160	11 490 – 11 810	-11.3 ± 0.4
ANU 3682	T79 174,175	27 600 ± 900	26 700 – 28 500	-11.2 ± 0.4
ANU 3329	Simbu limestone	100.4 ± 0.9		-7.1 ± 0.4

Anomalous dates

ANU 2562 was an attempt to date the top deposits of Stratum A at a time (1979) when the full complexities of the stratigraphy were not yet understood. Because of the scarcity of easily dated materials, snail shells, often fragments only, were amalgamated from a number of different squares; A1:1, B3:0, C3:1, D3:1, PQR71:1, X3:1 and A1:2. It is now realised that the snail shells from A1:2 come from the top of the Stratum B deposits and even the A1:1 shells may belong to Stratum B since the extremely thin nature of the top Stratum A deposits in the western areas of the site was not appreciated in 1979. The resulting range of 6150-6570 bp must reflect a contamination by older material. Recalculation using Table 2 from Polach, Golson and Head (1983:151) on the basis of presumed contamination by both samples from A1, using the weights of snails to estimate the proportions, produced a revised date of within the last 1000 years which is satisfactory.

There remains one anomalous date of 16,220-16,780 bp produced from a number of snail shells from various squares (ANU 2563) in an attempt to provide a date in 1979 for the deposits lying from 20 cm to 40 cm below the present ground surface.

Due to the scarcity of suitable dating materials, snail shells from four different locations were amalgamated for the sample, these being A2:2, X3:2, B4:1 and A3:2. The snails from this last location, it is now realised, belong to Stratum C redbrown sediments mixed with tephra-like pieces that lie under Stratum B. It is presumed that these Late Pleistocene snails caused the date to be considerably older than was expected. However, from the table provided in Polach, Golson and Head (1983:151), the resulting correction (using the weights of the snails to estimate the proportions) still produces an unsatisfactory result of about 14,500 bp. The remaining snail dates present no collection or technical difficulties and the discrepancies between bone and snail samples from one area required stratigraphic interpretation (see 3.5.5).

Flowstone and calcite samples

The $\delta^{13}\text{C}$ figures from the flowstones and calcite samples (Table 3.4) suggest that further correction is necessary on some of these, especially on the results from Flowstones 2 and 3 (ANU 2580 and 2581) and to a smaller extent on the calcite capping sample (ANU 2578).

Table 3.4 Radiocarbon dating from flowstone and calcite samples at Nombe

Lab. No.	Position	Date Age BP	Range Age BP	$\delta^{13}\text{C}$ ‰
ANU 2576	X3 Flowstone 1	10 250 \pm 100	9 250 – 11 250	-8.9 \pm 0.4
ANU 2579	A4 Flowstone 1	10 250 \pm 100	10 150 – 10 350	-8.0 \pm 0.4
ANU 2581	A4 Flowstone 2	13 900 \pm 130	13 770 – 14 030	+1.3 \pm 0.4
ANU 2580	A4 Flowstone 3	16 700 \pm 180	16 520 – 16 880	+0.1 \pm 0.4
ANU 2578	D71 Calcite capping	27 000 \pm 550	26 450 – 27 550	-3.1 \pm 0.4

Gillieson (1982:368-370) discusses the possible necessary corrections to the results from the calcite speleothems. He concludes that ANU 2576 and 2579 from Flowstones 1 **P1.4** were formed in isotopic equilibrium with the atmosphere but that the positive $\delta^{13}\text{C}$ results from ANU 2580 and 2581 from Flowstones 2 and 3 **P4** show that these flowstones were laid down under a different regime in isolation from atmospheric carbon dioxide. Gillieson and I agree that these sheets were likely, from the stratigraphic evidence, to have been formed as floe calcite within a gour pool (Section 4.6.3). J. Head (pers. comm.) believes that a correction factor of less than 2000 years should be applied to these results and to the result of ANU 2578 (calcite capping in D71 **P9**). This would mean that the revised dates become as follows:

ANU 2581 changes from 13,770-14,030 bp to c. 11,700-12,000 bp.

ANU 2580 changes from 16,520-16,880 bp to c. 14,500-14,800 bp.

ANU 2578 changes from 26,450-27,550 bp to c. 24,400-25,500 bp.

Uranium/thorium samples

Only two of the three samples submitted for uranium/thorium dating produced results and only one of those (McMaster 80055-1) was satisfactory in the stratigraphic interpretation of the site (see Section 4.5.4). The other sample (McMaster 80054-1) of thin calcite capping from a cemented clay block to the west of the Waisted Blade Crack in M71 ^{P9} gave the apparent result of 6800±900 bp which does not conform with the Pleistocene dates from other materials in the same stratum. Gillieson (1982:370) discusses the possibility that the sample suffered thorium depletion through bonding with phosphates in adjacent bone, thus producing a date that is much younger than the actual age of the sample.

3.5. MODEL OF SEDIMENT DEPOSITION AT NOMBE ROCKSHELTER

3.5.1 Introduction

The reconstruction of the development of the deposits at Nombe is based on the interpretation of the interlocking sets of evidence presented in previous sections:

- ☐ the **perceived stratigraphy** (Section 3.1.1);
- ☐ the **sediment analysis** carried out by Gillieson (Section 3.3);
- ☐ the laboratory **radiocarbon results** (Appendix B) and their subsequent interpretation (Section 3.4); and
- ☐ the analysis of **archaeological and faunal material** recovered from the deposits.

The stratigraphical sequence provided by this reconstruction forms the basis for the analysis and interpretation of the archaeology. Table 3.5 provides all the ¹⁴C results used in this reconstruction of the stratigraphic sequence.

Table 3.5 ¹⁴C results from Nombe in stratigraphic sequence

Stratum	Square	Spit	Catalogue number	Date range BP	Material	ANU Lab No.	
D2	A4	3	3	31 150 – 33050	Snail shell	2566	
D2	X3	6	1	29 100 – 30100	Snail shell	2565	
D1	D71	9	-	24 400 – 25500	Calcite	2578	Corrected
C8	A4	-	-	14 500 – 14 800	Flowstone	2580	Corrected
C8x	T79	174/175	-	12 650 – 13 650	Bone	3683	
C8	A4	-	-	11 700 – 12 000	Flowstone	2581	Corrected
C8	D79	-	46	11 210 – 11 590	Charcoal	2569	
C8	X3	-	-	10 150 – 10 350	Flowstone	2576	
C8	A4	-	-	10 150 – 10 350	Flowstone	2579	
B8	C3	4	40/46	11 490 – 11 810	Snail shell	3681	
B4	H71	7	-	9 370 – 9 930	Bone	3686	
B8	C3	4	40/46	7 480 – 9 160	Bone	3687	
B4	X3	3	55	6 620 – 6 860	Bone	3688	
B4	A1	4	17/21/24	5 760 – 5 989	Bone	3076	
B4	A1	3	14/19	6 290 – 6 470	Bone	3075	
B2	A1	2	13/16	5 630 – 5 990	Bone	3074	
B4	J71	5	-	5 230 – 5 450	Bone	3684	
B6	PQR71	5	-	4 870 – 5 310	Bone	3689	
A3	D79	-	99	3 110 – 3 730	Charcoal	2570	
A3	T79	-	120/121/122	820 – 980	Charcoal	3685	
A1	J71	3	-	100.4±09%M	Charcoal	3073	
C8x	B3	3	9	30 050 – 31 150	Snail shell	2568	
C8x	T79	-	174/175	26 700 – 28 500	Snail shell	3682	
B4x	A1	4	21/24	24 950 – 27 050	Snail shell	2564	

A preliminary reconstruction of the sedimentary history of Nombe was published in Gillieson and Mountain (1983). Subsequently, Gillieson (1982) put forward a detailed interpretation of the geomorphological evidence before the stratigraphic and chronological model was complete. Consequently, although much of Gillieson's analysis has been used as the basis of this reconstruction, there are some differences between the sedimentary histories of the site as presented in Gillieson (1982: Section 5.5) and the version presented here.

The site development model is presented in six stages representing the major processal events at the Nombe site from about 33,000 bp to the present. These stages do not necessarily represent the major stratigraphic divisions of the site and are not used in later analysis. A table summarising the deposition model is presented at the end of this chapter (Table 3.6). Figure 3.2 sets out a plan of the excavation.

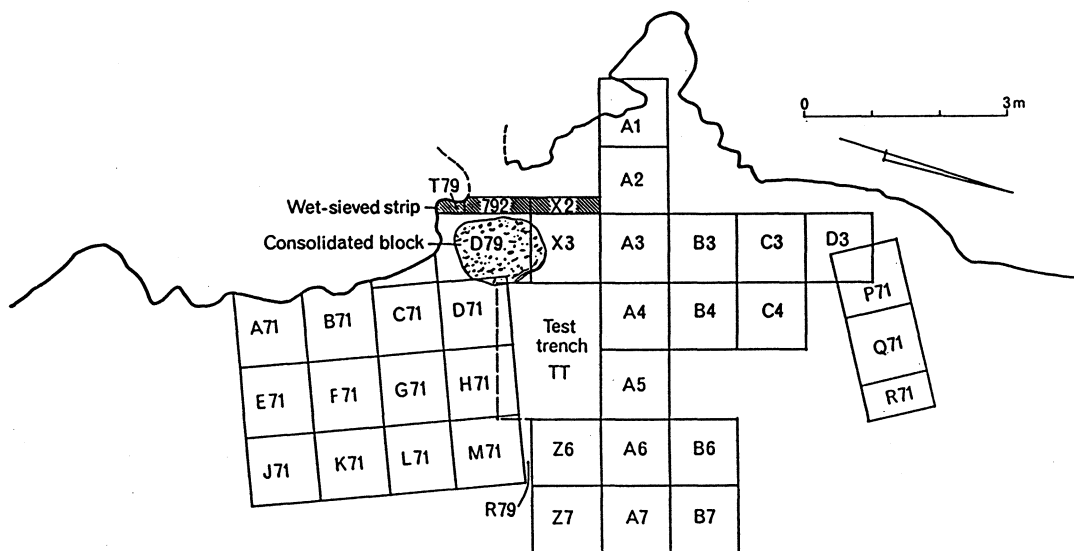


Figure 3.2 Nombe: plan of excavation squares

3.5.2 Stage 1

The deposits involved in this first stage are the basal, heavy, plastic, brown (D4) and redbrown (D3) clays and the ginger-coloured redbrown (D2) clays that lie over them. Both the D4 and D2 types are found in the central and western areas of the site *P1,2,4,5,6,7,8*. In the narrow cracks between the cemented clay blocks in eastern section of this site *P9* there is a very plastic redbrown clay (D3) that is similar in sediment composition to the heavy plastic brown clay, but of a redbrown colour, not easily distinguishable from the clays above. Only extremely small quantities of this clay were excavated due to its restricted position between cemented clay blocks that were not removed.

The heavy plastic clays at the base of the site are practically stone-free and contain little other material. These deposits contain a very high proportion of fine clay and occupy one extreme in Gillieson's Group Z (Figure 3.1). The overlying ginger-coloured redbrown clays appear drier and less plastic and contain many land snails and frequent pieces of limestone. The sediment analysis of two samples (18 and 107) shows that these deposits are more variable and mixed in origin than most of the other redbrown clays. Sample 107 falls into Group Z but sample 18 is part of a small subgroup of Group X with samples from the redbrown sediments all containing less fine clays and more silts than the underlying redbrown clays. This may suggest that

the slopewash material came from mixed origins and also that subsequent weathering and new deposition has altered the nature of the sediments.

Gillieson suggests (1982:347) that at this stage Nombe must have been rather damp and inhospitable, with an active stream emerging at the base of the cliff inside a small shelter or cave, running a winding course through banks of redbrown clays. This type of situation occurs today in some sites within the highlands of Papua New Guinea, for example at Selminum Tem, Southern Highlands (Gillieson 1982:182). The load of the stream would vary according to the rainfall. In times of heavy rain, large amounts of slopewash sediment would be deposited in the stream channel and between blocks of cemented clay or on the existing banks of the stream. The deposits would vary according to their original source and later weathering may also have caused variations in colour or texture, resulting in bands of recognisably different types of redbrown clay. Much of the material would be reworked with fresh deposition in times of flooding.

The evidence for such stream banks can be seen in the sloping nature of the basal redbrown clays in the central regions of the site **P1,2,4,5,6,7,8**. They slope strongly to the south-east, not merely from west to east as might be expected from the normal slope of deposits outwards from shelter to hill slope. The channel of the stream appears to have run to the south of this northern bank through squares T79 and 792, D79, D71-M71, R79 and possibly also Z6.

There is some evidence in the higher deposits for a slope on the southern side of this channel also; two pieces of cassowary bone were found to join which came from the basal levels of the thick bone stratum in H71:7 and the neighbouring K71:4 about 30 cm higher in level, indicating a considerable slope from south to north in the area where the southern bank of redbrown clays would be expected in underlying and unexcavated deposits. In Profiles 7 and 8 there is evidence of the rise of the redbrown clays at the south of the Wet-sieved Strip, which probably represents the southern side of the stream channel.

There are no radiocarbon dates from the heavy plastic brown clay but it must date earlier than the earliest date from the band of ginger redbrown clay that lies above it. There are two dates from this ginger redbrown clay, both on snail shell (ANU 2565 and 2566); ANU 2566, the earlier of the two, with a range of 31,150-33,050 bp, comes from the ginger band at the base of square A4 **P4** and ANU 2565, with a range of 29,100-30,100 bp, was collected from a slightly higher area of that formation in square X3 **P6**. This suggests that Stage began some time before 33,000 bp and continued at least to 29,100 bp. However, ANU 2578 from the calcite capping on a cemented block of clay at the base of the stream channel in D71, gave a corrected range of 24,400-25,500 bp and may provide a later *terminus ante quem* for the end of Stage 1.

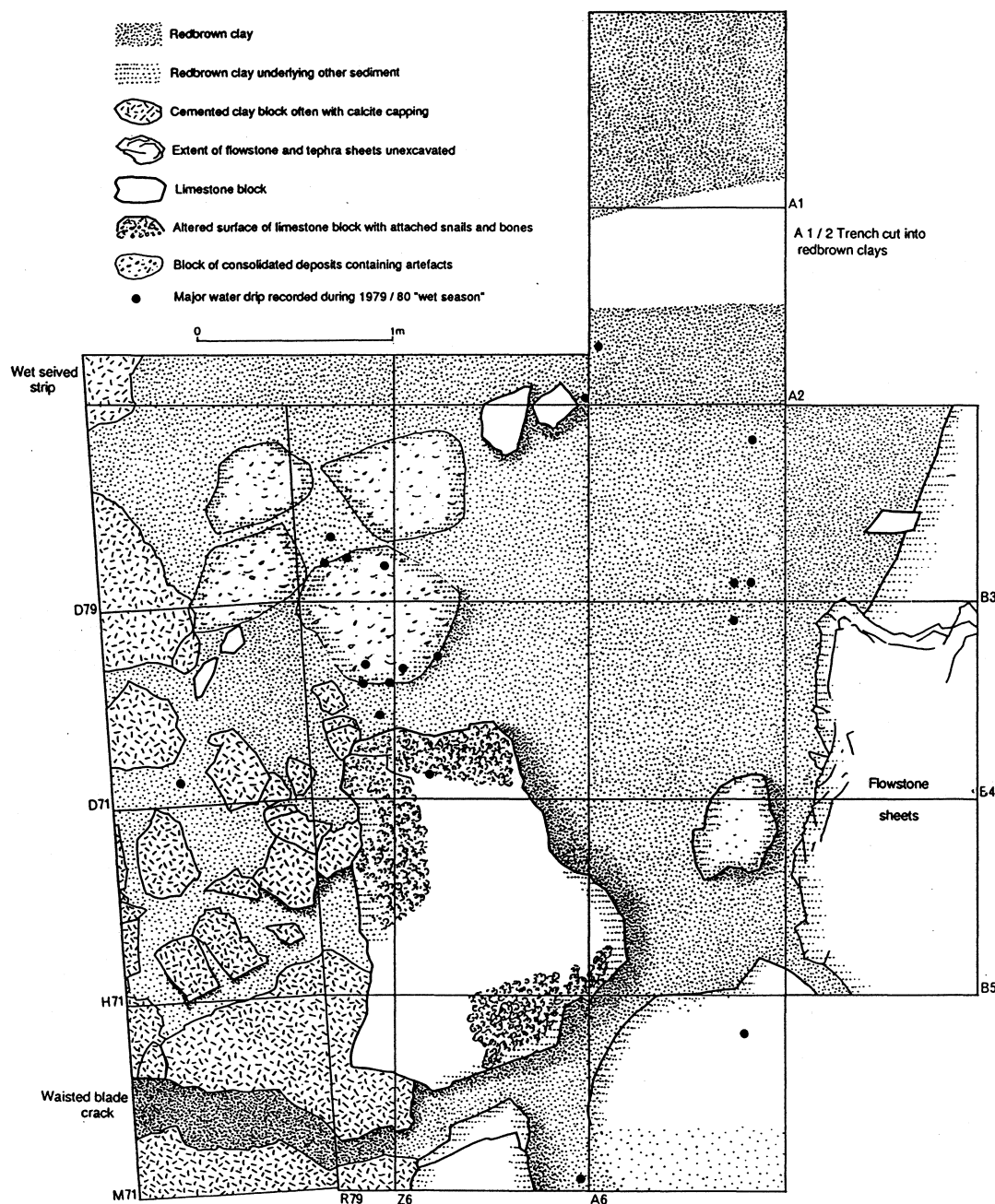


Figure 3.3 Detailed plan of central area of the site at completion of excavation and after removal of flowstones

3.5.3 Stage 2

During Stage 2 the remaining redbrown clays of Stratum D were deposited. Figure 3.3 is a detailed plan of the central areas of the site at the completion of excavation.

At the base of the stream channel as described in Stage 1, there is a 'floor' of cemented clay blocks running from M71, R79 and Z6 through the base of squares H71, D71 and into the eastern part of D79, often capped with a thin layer of calcite *P1,9,10,11*. The calcite has apparently been deposited from active roof drips thus cementing the clay underneath to form resistant blocks (Gillieson and Mountain 1983:56). This suggests that the clay at the base of the stream channel was exposed for sufficient time for the formation of such a 'floor' to take place and that the stream was not active during this process.

The remaining redbrown clays that do not occur in perceptible layers must have been laid down as fine clay deposits from the spring which filled in the original stream channel over the 'floor' of blocks and the banks of earlier redbrown clays of Stage 1 (Gillieson 1982:390). Sedimentary analysis shows the close similarity between nine samples taken from this type of deposit (sediment samples 46 and 49 *P9*, 37 *P6*, 30 *P5* and samples 22, 1, 2, 3 and 15 *P4* together forming much of Group Z (Figure 3.1). By the time the redbrown clays ceased to be deposited, their total depth in the central and western parts of the site was as much as 70 cm *P9*. The uniformity of the sediment, and the lack of periodic layering, gives the impression that these sediments were laid down relatively quickly. However, the earliest and latest dates of Stage 2 show that it lasted about 9500 years. It would be surprising if during that length of time there were no visible variations in the deposits. This suggests that there may be a time gap in the sequence of deposits between the top of the redbrown clays and sediments and the base of the overlying flowstone formation - in fact a disconformity. No visible disconformity appears in the stratigraphy of the redbrown clays but it is possible that periods of erosion have removed some deposits either at one or possibly at several periods of time during Stage 2. It is more likely there was a disconformity in the deposits between the top of the redbrown clays and Flowstone 2.

Gillieson (1982:347, 427) suggests that during this period of deposition the process of solutional enlargement in the underlying joints of the limestone must have been increasingly active. Gradually the water flow and its associated load of slopewash deposits would have been taken further down into the karst limestone system, eventually replacing the spring outlet and stream at Nombe with a spring that emerged farther down the slope of the Lombila doline. Such a spring exists today. Deposition of the redbrown clays would have become more sporadic and the balance between depositional and erosional factors must have become critical, until no further redbrown clay was deposited in the Pleistocene period.

Several large limestone blocks must have fallen from the roof and become lodged in the build-up of the redbrown clays. The large block in White's Test Trench **P11** probably assisted in the formation of the northern bank of the stream and other smaller blocks in A6 **P4**, Z6 **P10**, B3 **P1,2** (Figure 3.3) and in the northern area of the Test Trench probably fell on this northern bank. Further to the north again, a large block was deposited on top of the clays **P1,2** bringing the ground level in the area of squares B3, C3, D3, B4, C4 and PQR71 well above that of the more southern regions of the site.

A sample from the calcite capping of a cemented clay block at the base of D71 **P9** (ANU 2578) gave a range of 24,400-25,500 bp (corrected from 26,450-27,550 bp) indicating that the channel was still open at that time and that Stage 1 had not yet ended. There must have been lengthy periods when water flow was minimal, while the calcite cappings formed on the clay blocks that were cementing in the base of that channel.

There are no radiocarbon determinations from undisturbed areas of redbrown clay from Stage 2, but ANU 2580 from Flowstone 3, overlying the redbrown clays in A3/4P4, shows that they had ceased to be deposited by 14,500-14,800 bp (corrected from 16,520-16,880 bp).

Three radiocarbon dates on snail shells that chronologically appear to belong to Stages 1 or 2 (ANU 2564, 2568 and 3682) are from material that was redeposited at a later stage of the history of the site.

3.5.4 Stage 3

Stage 3 is a complex period that involves the deposition of the sediments of Stratum C. Figure 3.4 is a detailed plan of central area of the excavation before the removal of flowsheets.

The sediment composition of the deposits at the top of the redbrown clay of Stratum D and into the redbrown sediments of Stratum C reflects the decline in slopewash components as seen in the decrease in clay content in Group X of the sediment analysis (Section 3.3.1). These samples in fact contain higher proportions of sands, gravels and silts than does Group Z from Stratum D deposits. Rates of deposition and constant water flow must have declined and allowed for the build-up of other forms of deposit. The increased sands, gravels and silts were possibly deposited by occasional periods of flooding when water carrying coarse materials escaped through the old stream outlet at Nombe.

Increasing quantities of calcium carbonate were being laid down in thin flowstone sheets in the top levels of the redbrown clay in A4/A5 **P4**. These are visible when cut in section but too fragile to survive excavation. The first sheet that was thick enough to

be removed and dated (Flowstone 3) lies on top of redbrown clays, immediately under redbrown sediments. The corrected date of that flowstone (ANU 2580) at 14,500-14,800 bp provides a *terminus ante quem* for those redbrown clays, as already noted in Section 3.5.2.

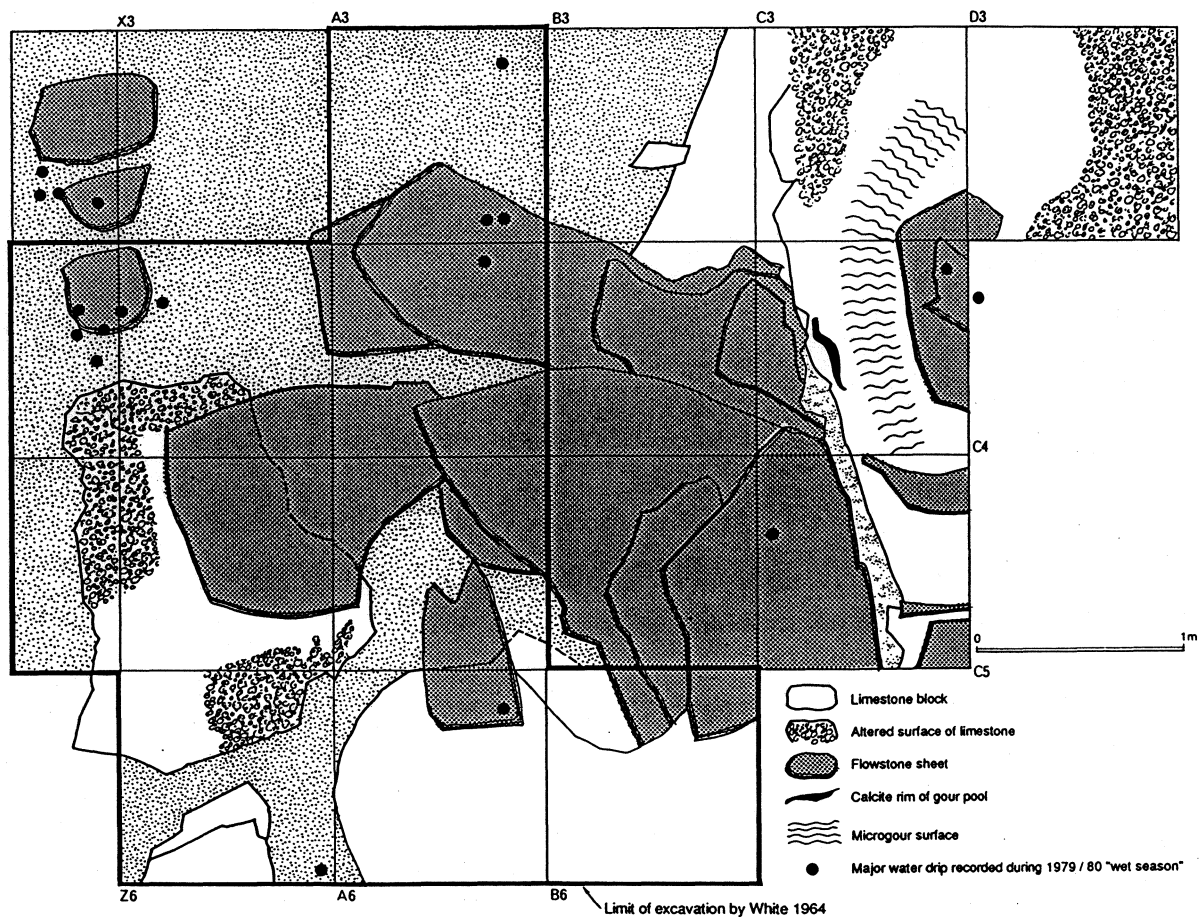


Figure 3.4 Detailed plan of excavation (central area before removal of flowstones)

The build-up of increasingly thick flowstone sheets (for example Flowstone 2 ^{P4}) in the top of the redbrown clays and redbrown sediments seems to indicate a change in the nature of the depositional processes on the site that is not merely accountable by the decrease in deposition rates. Gillieson (1982:428-430) puts forward the theory that thinning of the vegetation on the limestone slopes above the site led to an increase in the amount of available carbon dioxide, which in turn would be reflected in cave drip hardness:

Degassing of water films in the cave with a higher carbonate content would result in a higher rate of flowstone formation. The dense root mat under *Nothofagus* forest may produce higher soil CO₂ levels. Although no work has been carried out on this in Papua New Guinea, vegetation change during the last glacial maximum may have resulted in increased rates of flowstone formation at Nombe. To test this hypothesis it would be necessary to monitor levels of soil and cave CO₂ and cave drip hardness in Papua New Guinean karsts under different vegetation types. (Gillieson 1982:430)

Vegetation changes are known to have occurred as a consequence of the changes in climate involving a decrease in temperature and changes in precipitation in the last phase of the Pleistocene (Bowler *et al.* 1976:389). As a result, the vegetational zones were at lower levels than today. G. Hope (1983b:40) posits that the upper limit of the montane forest, now about 3900-4000 m, was about 2000-2400 m during the period from 20,000 bp to 15,000 bp. He suggests that above that level trees were sparse and shrubs and tree ferns were scattered in open grasslands. The top of the ridge above Nombe is just over 2000 m, rising to the nearby peak of Mount Elimbari at 2850 m. The montane forest assumed to have been growing on the exposed slope above Nombe during most of the Pleistocene could have suffered from this gradual altitudinal decline, possibly resulting in thin *Nothofagus* forest covering much of the slope with very few trees existing at or near the ridge top. Gillieson's theory also allows some sort of clearance (natural or artificial) of the vegetation above Nombe (Gillieson 1982:430), but without supporting evidence this is only speculation.

As the rate of water flow decreased and the remaining clays acted as impervious barriers with the fallen rocks, ground water must have accumulated in pools, allowing the build up of a large pool in the northern (higher) part of the site. Evidence supporting this reconstruction comes from the large blocks of sediment that occur between Flowstones 2 and 3 in squares A3-5. These probably represent tephra that fell into standing water and settled in thick laminations. Any excess water from this pool would overflow down the face of the fallen limestone block in C3/D3 and its accumulated accretions ^{P1,2}. Eventually, a gour pool (a pool bounded by a rib or ridge of calcite, formed by precipitation from water flowing over the rim) developed above Flowstone 2. The gour pool rim can best be seen in Figure 3.4 and Plates 11 & 12 which clearly show the fragment of curved calcite rib that remains on the top of the

south tip of the limestone block in C3/C4. There is also evidence of microgours (miniature gours with associated tiny pools of the order of 1 cm wide and deep) that formed as the water trickled over the limestone block to the north ^{P1}. This also implies that Flowstone 2 and maybe also Flowstone 3 were laid down as floe calcite sheets within a water pool, accounting for the differences between the $\delta^{13}\text{C}$ figures for radiocarbon samples from these flowstones (ANU 2580 and 2581) and the more normal $\delta^{13}\text{C}$ values for flowstones dated by ANU 2576 and 2579 (Table 3.4). That water pool may have been formed on older clay deposits that were re-exposed through eroding forces removing subsequent clays.

The considerable amount of volcanic ash that found its way into this pool and built up above Flowstone 3 seems to be mixed with fire ash towards the top, producing a vesicular deposit which is less clearly laminated (Plate 10). Finally, when the tephra-like blocks almost completely filled the pool, it was capped by another flowstone, Flowstone 2. A final flowstone, Flowstone 1, is stratified above Flowstone 2 in A4/5 with some redbrown sediments separating the two ^{P4}.

The consolidation of the tephra-like blocks in the pool must have caused standing water to drain away. Continued enlargement of the underlying solutional joints and subsequent slipping of the underlying clays probably accounted for the subsequent break-up of the soft tephra-like blocks and rigid crystalline flowstone sheets. This allowed, at a later date, more recent sediments to penetrate into those cracks. Further accumulation of some redbrown sediments continued but deposition in the period following the formation of Flowstone 1 seems to have been extremely slow until the build-up of Stratum B deposits began in the next stage of development.

A number of dates have been produced from this series of well stratified flowstones (Plate 4). The date of Flowstone 3 (ANU 2580) has already been discussed since it provides a boundary for the division between Stages 2 and 3 at a date of 14,500-14,800 bp (corrected from the apparent date of 16,520-16,880 bp, see Section 4.4). Flowstone 2 (ANU 2581) dates to 11,700-12,000 bp (corrected from 13,770-14,030 bp). The tephra blocks that lie between Flowstones 2 and 3 ^{P4} must date to the period between ANU 2581 and ANU 2579. There is some probability that the volcanic event that caused these tephra is the same as that which resulted in the tephra known as Ep Ash found in Kuk Swamp, Mount Hagen (Gillieson 1982:387; Gillieson and Mountain 1983:56). Flowstone 1 has been dated (ANU 2579) with a range of 10,150-10,350 bp. This correlates well with two dates, ANU 2576 with a range of 10,150-10,350 bp and a uranium/thorium date (McMaster 80055-1) with a range of 9,100-15,300 bp, both of which come from a thick flowstone that occurs in D79/X3 ^{P1,6} suggesting that this also is Flowstone 1. If so, this must have been formed as a steeply dipping deposit, sloping south and east, lying over redbrown sediments that had built

up partly on the tephra-like deposits in the pool and the overlying Flowstone 2 and partly over the area of A3 to the south of that pool **P1,4**.

This hypothesis is compatible with the date of 11,210-11,590 bp (ANU 2569) on charcoal extracted from a block of consolidated deposit lying underneath the flowstone in D79/X3, as well as with the presence of tephra-like pieces that are present in the redbrown sediments on which that consolidated block lies **P6**. Sediment sample 38 comes from these tephra-like pieces and, like sample 10 from the tephra-like block in A4, belongs to sediment Group Y. However, the two samples show considerable differences, which should be expected as sample 10 came from the top of the A4 block and may have other materials such as fire ash mixed in with the tephra. The tephra-like blocks lying over the redbrown clays in D79 **P1** were not included in the sediment analysis, but their stratigraphic position and similarity in physical appearance to the tephra-like blocks in A4/5 suggest that they originate from the same volcanic event as caused the thick deposits there. There is a possibility of a disconformity in the sediment build-up between these redbrown clays and the tephra-like blocks lying on top.

The top of the Stratum C redbrown deposits is dated to 12,650-13,650 bp by ANU 3683, a bone sample from T79 **P7-9**. However, since there has been disturbance above this (caused by human activity during Stage 4, see Section 3.5.5), it is possible that the top of Stratum C was truncated in this area of the site and that the date of 10,150-10,350 bp (ANU 2576 and 2579) from Flowstone 1 in A4/5 and D79/X3 is a more reliable date for the end of this stage.

A date which appears to be chronologically related to Stage 3 is ANU 3681, 11,490-11,810 bp, from the basal red clays over the fallen limestone block in C3 **P2**. Gillieson (1982:354) found that the red clay at the base of C3 (sediment sample 75/71 **P2**), consisting of clays and organic silts, is a member of Group Z along with most of the other redbrown clays. Since there is an associated bone date of 7480-9160 bp (ANU 3687) from precisely the same location without any apparent reason for the difference in age, this area is difficult to interpret stratigraphically. Further analysis of the archaeological materials within this deposit may clarify the position. There could have been very spasmodic accumulations of red clay in the basal pockets of the limestone block as slopewash sediments from the late Pleistocene into the early Holocene.

3.5.5 Stage 4

At this stage in the sedimentary and chronological history of Nombe there occurs a feature that causes disturbance of the earlier redbrown clays in the western part of the site. A trench was found deliberately cut into the basal clays in A1/2, running north-south across the squares (Figure 3.3 **P4,5**). The excavated material seems to have been

subsequently dumped to either side of the feature over Stratum C deposits to the east ^{P2} and Stratum D deposits to the west ^{P4,5}, where the brown gritty loam and red gritty sediments are thought to be upcast from the digging of Trench A1/2. The basal filling of this trench contains archaeological material that is very similar to that from the redbrown clays (Section 3.3.1) but sediment sample 23 falls into the mixed group of sedimentary deposits, Group X, (section 4.3.1). Above this mixed filling lie pieces of tephra-like material similar to that found between Flowstone 2 and 3 in Profile 4 (sediment sample 19 falls into group Y, Section 3.3.1). The filling is sealed by the thick layer of brown loam and ash deposits containing large amounts of bone designated as Stratum B. Human action was certainly responsible for the excavation of this A1/2 Trench and evidence for this statement and the possible reasons for the activity will be discussed in Chapter 4.

Two puzzling phenomena occurred in the area of the A1/2 Trench:

- ❑ pieces of extinct and often heavily burnt bone had been found in several archaeological units rather high in the stratigraphy where they had originally been interpreted as in situ; and
- ❑ several radiocarbon dates on snail shell from similar archaeological units of similar stratigraphic height and close to the A1/2 squares, gave results that were more in keeping with stratigraphical positions low in Stratum D. In two cases such dates were accompanied by much later dates on bone recovered from the same archaeological unit (ANU 2564 and 3076, ANU 3682 and 3683).

An 'upcast' theory satisfactorily explains these dates. A red gritty deposit containing Pleistocene snail shell (ANU 2564 at 24,950-27,050 bp) from the A1/2 Trench has been thrown up from the digging of the A1/2 Trench and later become incorporated with the base of the succeeding Stratum B deposit (ANU 3076 at 5760-5980 bp) in A1:4 ^{P4} and, in the case of the samples from T79 174 and 175, Pleistocene snail (ANU 3682 at 26,700-28,500 bp) was thrown on to the existing material at the top of Stratum C (ANU 3683 at 12,650-13,650 bp) ^{P7,8}.

Another snail date of 30,050-31,150 bp (ANU 2568) came from shells recovered from a very mixed deposit in which redbrown sediments, very large pieces of limestone, many large snail shells and blocks of tephra-like material occurred together immediately over the top of the redbrown clays in B3 (Profile 2). Sediment sample 20 from the same archaeological unit proved to be fairly mixed in origin and belongs to the intermediate Group X (see Section 3.3). Whether this situation can be explained by the 'upcast' theory is uncertain.

Close scrutiny of the original field profile drawings does not always clearly indicate the limits of the dumping or disturbance. Wherever there is any doubt as to the stratigraphic integrity of any archaeological unit, it has been designated with an X

after the stratum letter and not included in any analysis of stratum content. Since the event of trenching and upcast occurred, the dumped materials have merged into the sediments on to which they were thrown. In some cases (for example in the Wet-sieved Strip ^{P7,8}) the weathering processes appear to have broken down the original composition of the clays, resulting in a mixture of materials at the top of the redbrown area that originate from Stratum D, in a matrix too similar to the underlying Stratum C deposits to be now recognisable. The extent of the disturbance might be clarified by further sediment analyses from samples near the 792/X2 boundary where it appears from the profile that the possible areas of disturbance are at their limit. There is no sign of dumping in X3 either from the profile or from ¹⁴C results.

The A1/2 Trench must have been dug after the redbrown clay had ceased to be deposited but before the accumulation of the thick Stratum B deposits that run undisturbed over the A1/2 Trench filling. This brackets the period of time to between the date of Flowstone 3 (ANU 2580) at 14,500-14,800 bp and the oldest known date of Stratum B, which for the entire site is in H71 ^{P9} at 9370-9930 bp (ANU 3686), although the basal date for the Stratum B deposits immediately above the trench infillings are younger, at 5760-5980 bp (ANU 3076 ^{P4}). There are no other helpful dates for pinpointing this stage. A substantial piece of the tephra-like material, containing both laminations and vesicular structure, such as occurs in the blocks found in the adjoining squares A3-5, has tipped into the filling of the A1/2 Trench ^{P4}. It may have been in position on the edge of that trench when it was dug, but due to gradual erosion of the sides, it could have been dislodged and tipped into the half-full trench. A possible alternative theory is that the tephra post-dates the trench and the block was deliberately put or accidentally fell into the trench whilst infilling was proceeding. The disturbed nature of the redbrown sediments and ¹⁴C dates from areas on the edge of the A1/2 Trench ^{P4} seem to suggest the later theory with the tephra-like block forming over upcast from the Trench. If this theory is correct, the A1/2 Trench must have been dug before the formation of that tephra-like material which, because of its strong similarities with the A3/5 tephra-like blocks, may date to between 14,800 and 11,700 bp, the bracketing dates for Flowstones 3 and 2. There is an apparent minimum age of between 10,000 and 12,000 bp for Ep tephra (J. Golson pers. comm.), which has strong similarities to the Nombe material.

3.5.6 Stage 5

The next stage of deposition at Nombe involved the accumulation of Stratum B. This stage shows an increase in human activity at the site, with the deposition of large amounts of burnt fragmented bone and artefacts. The very thick bone level Stratum B is clearly visible in the western parts of the site ^{P4,5,6,7,8}.

In some areas Stratum B is very thin, having suffered from erosion; for example, under a prominent overhanging rock pendant in the roof over A4/B4, above the jagged edge of the underlying tephra and flowstone sheets ^{P4} and towards the eastern margins of the sheltered ground in square M71 ^{P9,10}.

A bone sample from H71 (ANU 3686) from the base of Stratum B, close to the top of the redbrown clays ^{P9} provides the oldest date for this accumulation at 9370-9930 bp. On this evidence a date of 7480-9160 bp (ANU 3687) from a bone sample at the base of C3 ^{P2} would belong chronologically to Stratum B. However, in fact it lies about 20 cm below the base of a brown loam with red flecks that continues the line of the more normal thick bone layer of Stratum B from the adjoining square B3. It is hard to be sure of the chronology of the upper strata in squares C3 and D3 but it may be an indication that Stratum B deposits were accumulating differentially in various parts of the site. It suggests that for the first 3000 years of the Holocene, thick Stratum B deposits accumulated at first in the hollow over the top of the in-filled Pleistocene stream channel in squares D71-M71, while there were scattered deposits in other areas such as C3.

There is also an older date from a snail sample (ANU 3681) from the C3 basal clay (11,490-11,810 bp). This may indicate that eroding agents (including humans) were extremely active and there was frequent removal of many sediments during the last part of the Pleistocene and early Holocene thus allowing bone and snail in close proximity to differ in age by some 2000 years.

The thick bone stratum in the west of the site has been well dated by three stratified samples from the top (ANU 3074 with a range of 5630-5990 bp), middle (ANU 3075 with a range of 6290-6470 bp) and base (ANU 3076 with a range of 5760-5980 bp which due to contamination by acid insoluble soil failed to give a collagen result).

These results come from nearly 50 cm of Stratum B in A1 ^{P4} and the extremely small range of only 5630-6470 bp suggests that the deposit was built up very rapidly. ANU 3688 from the base of Stratum B in X3 ^{P6,11} with a range of 6620-6860 bp may provide a more likely date for the beginning of the build up of the bone level at the west and centre of the site than ANU 3076.

The date at which the period of intense human activity producing Stratum B declined is bracketed by ANU 3074 from the top of Stratum B in A1 ^{P4} with a range of 5630-5990 bp and the oldest dates for the overlying Stratum A deposits (ANU 2570, 3110-3730 bp). There is a bone sample (ANU 3684) from the Stratum B deposits at the bottom of the excavation in an outlying part of the site - J71 ^{P10}. This gives a range of 5230-5450 bp. which correlates well with the other dates produced.

ANU 3689, at 4870-5310 bp, is a little younger than other Stratum B results elsewhere on the site but actually dates the redbrown clay in PQR71. These clays obviously represent a different episode of deposition from the Pleistocene redbrown clays in the south and central areas of the site. Clays were deposited by fluvial action at different periods of the development of the site. Gillieson (1982:356) hypothesises that this wedge of redbrown clay in the northern squares, which was not included in the sediment analysis, was due to flooding from north of the site, causing slopewash deposits to be brought down and deposited over the fallen limestone block that lay on top of Pleistocene redbrown clay. Other redbrown clays found towards the drip line also appear by their archaeological contents to be Holocene in date and must have been laid down during the period of the formation of Stratum B over the top of the eroded Pleistocene redbrown clays, for example in Z6 (see discussion of Stratum B in Section 3.2.2). Severe flooding, such as is suggested by Gillieson, may also account for the formation of Channel D79, described below (Section 3.5.7).

Other dates from higher levels in Stratum A are all considerably later and do not assist in dating the change from Stratum B to Stratum A. It seems probable therefore that Stratum B in the western areas of the site (squares A1/2) ends about 5600-6000 bp when the deposits reached within 20 cm of the roof level at the back of square A1 ^{P5} and possibly when the area was used for a burial ^{P4}. In areas where the deposits were still within comfortable distance of the roof, it is possible that the top of Stratum B deposits are a little later in date. Elsewhere the change from Stratum B to Stratum A seems to have occurred sometime after the dates that give the ranges of 4870-5310 bp from PQR71:5 (ANU 3689) and 5230-5450 bp from J71:5 (ANU 3684).

3.5.7 Stage 6

At some stage after the period between about 5450 bp and 4900 bp the human activity on the site altered. The change from Stratum B to Stratum A deposits involves a purely archaeological phenomena, namely a decrease in the rate of accumulation of deposits and in the density of artefact deposition. However, the site was still frequently used, either on a more periodic basis or by people concerned with different activities than those which produced the bone-rich levels of Stratum B.

There is a date of 3110-3730 bp (ANU 2570) from Stratum A deposits lying 1.10 m below Datum A on the south side of the Consolidated Block of deposits in D79/X3 at a level where Strata B or C deposits might be expected. Profile 6 shows that this charcoal sample was collected from a block of deposit only a few centimetres above the level of ANU 2569 which was charcoal from another block of deposit stratified under Flowstone 1 and dating to 11,210-11,590 bp. The explanation lies in the build-up of the large Consolidated Block of cemented deposits in D79/X3 and its effect on drainage.

Profile 1 shows how the deposits lying over the layer of tephra-like blocks became cemented together with calcium carbonate from the overhanging roof boss, eventually sealing on to the roof itself. This may have effectively created a permanent blockage to the temporary drainage necessary after heavy rain. Local inhabitants say that in periods of extremely heavy and prolonged rain they can remember a small stream emerging from the site, presumably fed from the internal karst system within the limestone, probably through solution tunnels. At the very end of the 1979-80 field season, after excavation of the Wet-sieved Strip had been completed, some surface deposits were removed from the next strip to the west (T792, 792.21 and 792.22). These deposits had effectively sealed the eastern entrance to another chamber. In the ceiling of this chamber were many small roof pendants and at least one chimney. It is quite possible that such drainage chimneys connect directly to the end of the passage that exists inside High Cave, the cave that is situated in the cliff face to the south of Nombe rock shelter (see Section 2.1.3 and Figure 2.5). Through such channels, it is likely that excess flood water can still drain out through the newly discovered chamber and to the south of the Consolidated Block D79/X3 through squares C71/D71, H71 and M71, following the line of the Pleistocene stream channel. Indeed, it had been noted during the first excavations in 1971 that there was a change in the deposits at the back of C71, where there were very dark humic, damp sediments in a crack (the Drainage Crack, Figure 3.5) between the overhanging rock boss at the top of the Consolidated Block D79/X3 and the cliff face to the west of squares A71, B71 and C71.

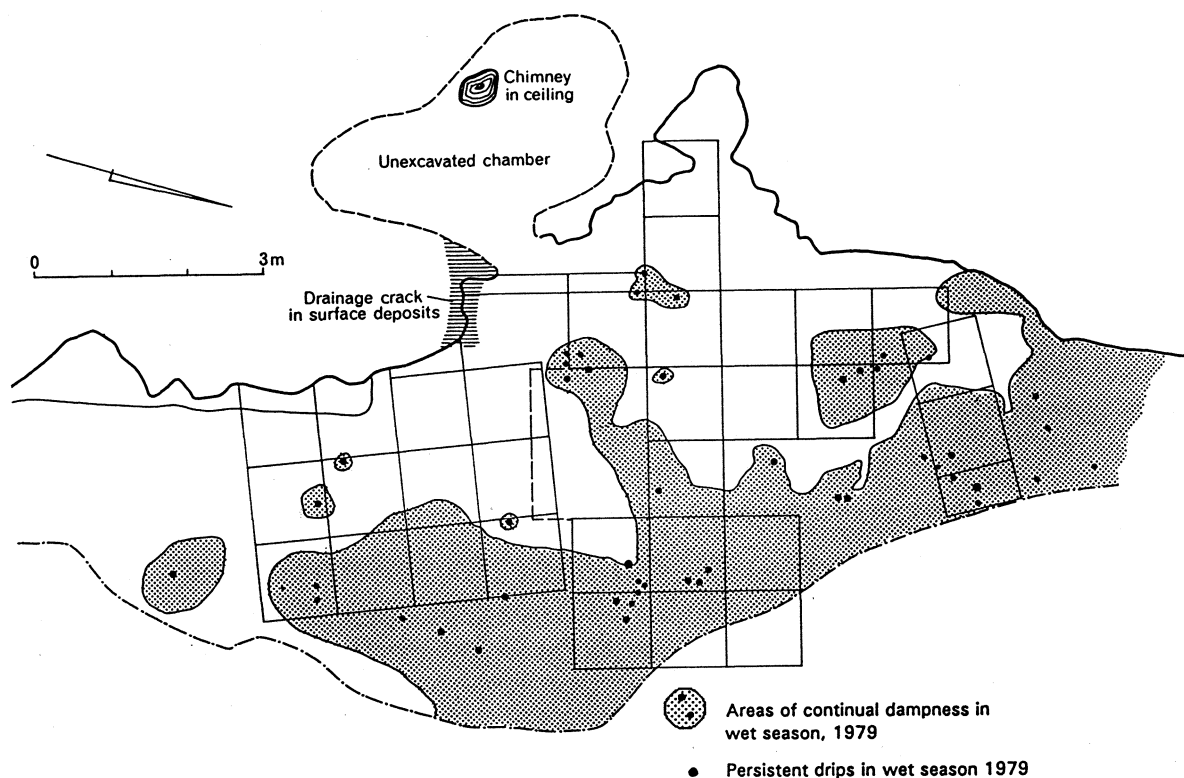


Figure 3.5 Nombe rockshelter wet/damp areas as recorded in 1979

It would seem that the area of D79/D71 had acted as the outlet of the Pleistocene stream for many years and that even after that old channel was filled with redbrown clays, the area had still served as a sump for deposition and drainage. After the final sealing of the Consolidated Block in D79/X3 excess drainage had to be channelled to the south of the area gouging out another channel in the Holocene deposits. This has led to a severe disconformity within the archaeological deposits within a small zone of D79, so that Strata C and B materials from within the body of the Consolidated Block D79/X3 are now higher than Stratum A deposits lying in Channel D79 immediately to the south of them.

The date of 3110-3730 bp from ANU 2570 ^{P6} shows that the Consolidated Block D79/X3 was already blocking the passage of flood drainage by then and that the Channel D79 had already formed.

A bone date from J71:5 in Stratum B (ANU 3684 ^{P10}) gives the range 5230-5450 bp, suggesting that the overlying 50 cm of undifferentiated brown sediment throughout the 1971 grid has accumulated over the last 5-5500 years (cf. Profile 9) whereas charcoal from J71:3 dates to within the last hundred years (ANU 3073). This charcoal was probably collected from a cooking pit that was dug from much nearer the present surface but, due to the powdery soft nature of the sediments in Stratum A, no

trace of the outline of the pit excavation remains. However, an electro-spin resonance estimation on a piece of bone from the same level as the charcoal suggests that it is certainly much older than the charcoal.

Stratum A deposits vary greatly in depth. White found four joining pieces and a chip of a polished stone axe (White 1972:127) in a number of squares at different depths below the existing surface ^{P4}. Those pieces from the more western squares were close to the surface but those from the squares further to the east are up to 0.8 m below Datum A indicating that the build-up of Stratum A deposits in the front of the shelter was considerable. A charcoal sample from the very top black, humic deposits of Stratum A in the Wet-sieved Strip (ANU 3685 ^{P7,8,9,11}) with a range of 810-970 bp, shows that the deposits accumulation has tended in very recent time to be towards the eastern, more protected areas near the sides and back of the present cave.

Table 3.6 Depositional model: summary of stages of sediment deposition at Nombe

Stage	Bracketing Dates (BP)	Sediment description	Sediment units	Reconstructed site Environment
6	Present to (4870-5310)	<ul style="list-style-type: none"> • Light dusty sediment • Darker sediment 	A1 A2	This stage continues the pattern of stage 5 with a decrease in the quantity of artefacts and bone.
5	(4870-5310) to (9370-9930)	<ul style="list-style-type: none"> • Brown loams with many artefacts and bones • Mixed loams and clays • Redbrown clays 	B2, B4 B6,B7,B9 B3, B8	During this stage there was a build up of thick dark brown loam with many artefacts and heavily burnt bones in the main body of the cave while in other parts of the site there were clays, probably deposited by flooding or water seepage.
4	Some period between (9370-9930) & (14 500-14 800)	<ul style="list-style-type: none"> • Probable upcast from excavation of trench A1/2 	C8X, B5X	This appeared to be a brief stage when humans dug a short trench into earlier sediments, depositing the upcast onto the current surface of the cave
3	(10 150-10 350) to (14 500-14 800)	<ul style="list-style-type: none"> • Flowstones • Redbrown sediments • Tephra blocks 	C8 C8 C8	There was a great deal of sedimentary activity during this stage
2	(14 500-14 800) to (24 400-25 500)	<ul style="list-style-type: none"> • Redbrown clays 	D1, D5	These clays were deposited in a stream channel. There is a possible disconformity between the top of these clays and the overlying tephra and flowstone layers.
1	(24 400-25 500) to (33 050-31 150) and older	<ul style="list-style-type: none"> • Ginger coloured redbrown clay • Basal redbrown clay • Basal brown clay (Some of these clay blocks are capped with calcite layers)	D2 D3 D4	These sediments are in the slopes of an active stream channel running through the cave and on the floor of this channel.