Lolmo Cave: A Mid- to Late Holocene Site, the Arawe Islands, West New Britain Province, Papua New Guinea

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ARCHAEOLOGICAL EVIDENCE from the Bismarck Archipelago, north of Papua New Guinea (Fig. 1), has in recent years provided a sequence of change spanning the last 35,000 years (Allen and Gosden 1991). The main sets of evidence derive first from caves on New Ireland, the earliest occupation of which begins 35,000 years ago and continues down to the mid-Holocene. This is then followed by rich Lapita assemblages from open beach sites on New Britain, Mussau, and elsewhere, dating from 3500 B.P. onward. There is now a growing body of evidence spanning the period 6000 to 3500 B.P. The Lapita period is seen by many as a major point of discontinuity in the sequences from the area, because of immigration of Austronesian speakers from the west (Bellwood and Koon 1989; Kirch 1988; Spriggs 1989). However, given the increasing evidence of continuity from the pre-Lapita to the Lapita period, this hypothesis is now in need of reassessment.

The site reported here, Lolmo Cave in the Arawe Islands (Fig. 2), is important because it spans the last 6000 years, encompassing both the Lapita period and its immediate antecedents. The material contained in the cave provides some evidence of continuity from the pre-Lapita period through to the Lapita period, but also some evidence of discontinuity. Lolmo Cave also represents only one point on the landscape and does not appear to have been a major focus of habitation. In this it is similar to the few sites reported from the immediate pre-Lapita period elsewhere, which are also caves and shelters (Spriggs 1991a). Lolmo may thus represent a class of sites with similar characteristics and provide insights into broader patterns of change.

This paper aims to present the major sets of data from Lolmo Cave and to discuss the light this throws on the mid- to late Holocene periods. A broader context is provided by drawing on data from other contemporary sites, so that we

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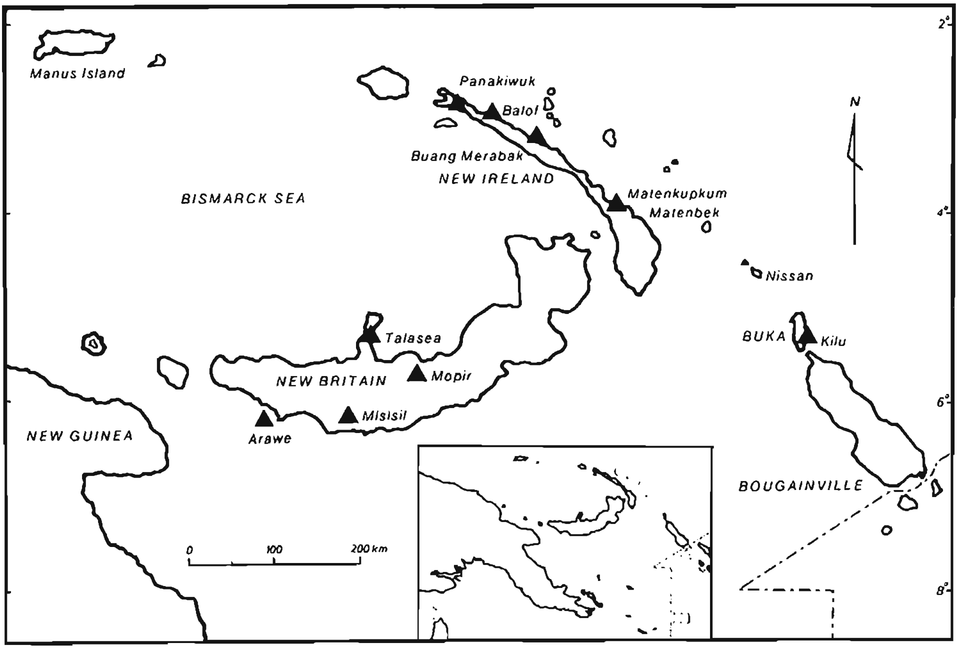

Fig. 1. The Bismarck Archipelago, with the sites mentioned in the text.

can discuss the problems of comparing the archaeological records from different periods within the Bismarck Archipelago. Such a discussion of comparability will inform us as to how far and in what terms we can talk about the origins of the Lapita assemblages. We shall discuss the cave and its archaeological evidence first, before moving on to its broader significance.

THE FORMATION OF THE CAVE

Lolmo Cave (FOF [letters refer to Papua New Guinea site register]) is located on the southern side of Kumbun Island, within a cliffed section of coast (Fig. 2). However, the entrance is not in the cliff, but is set back about 50 m within a large gully, and faces into the gully and not out to sea. The floor of the cave is midway up the cliff, which is approximately 20 m high at this locality.

The cave consists of a single chamber (Fig. 3). The main entrance is a narrow passage between two large blocks of limestone and leads into the cave over some limestone boulders. There is a very low subsidiary entrance 5 m to the north, partially blocked with sediment and limestone rubble. This entrance was probably the point at which the major sediments washed into the cave, as is discussed below. It is this in-washing of sediment that caused the entrance to be partially blocked in the present. The southwestern wall of the cave is fairly straight and almost vertical. The ceiling is up to 10 m high along this wall and generally slopes down toward the northeast at 20–30° as a more or less planar surface (section B-B′, Fig. 3).

In the entrance section of the cave the floor slopes gently up to the northeast,

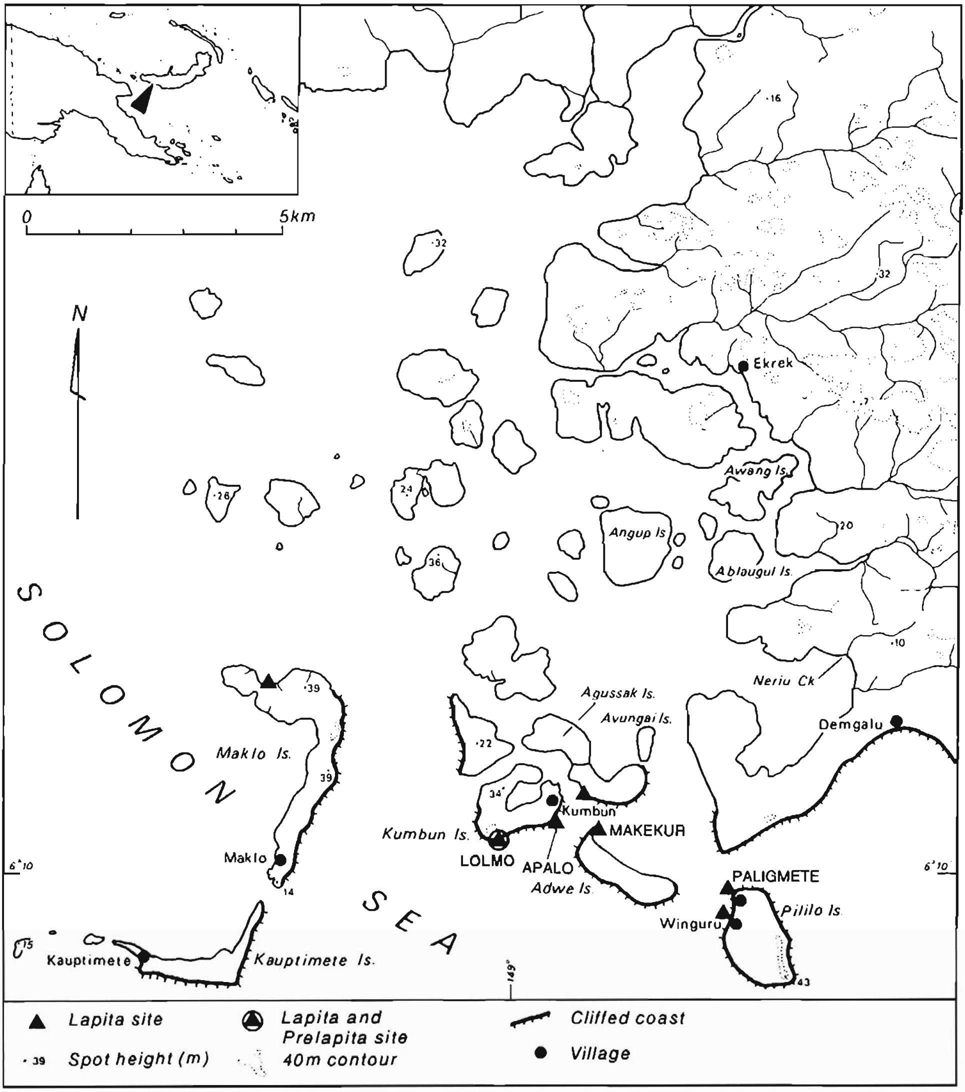

Fig. 2. The Arawe Islands, showing the location of Lolmo Cave.

toward the subsidiary entrance, where it almost meets the ceiling. The floor in this area, and elsewhere in the cave, consists of a mixture of fine-grained sediment and limestone rubble.

Unlike most caves in limestone, Lolmo was not formed by groundwater solution, although this has certainly modified parts of the cave. Instead it resulted from cliff failure, a process that is commonly responsible for the formation of small caves in a variety of rock types and geomorphic settings (e.g., sandstone cliffs along rivers [Young 1983]; precipitous fore-reef limestone slopes [Palmer 1986]). Running through the limestone cliffs of Kumbun Island are occasional vertical joints, oriented more or less perpendicular to the cliffline. So either side

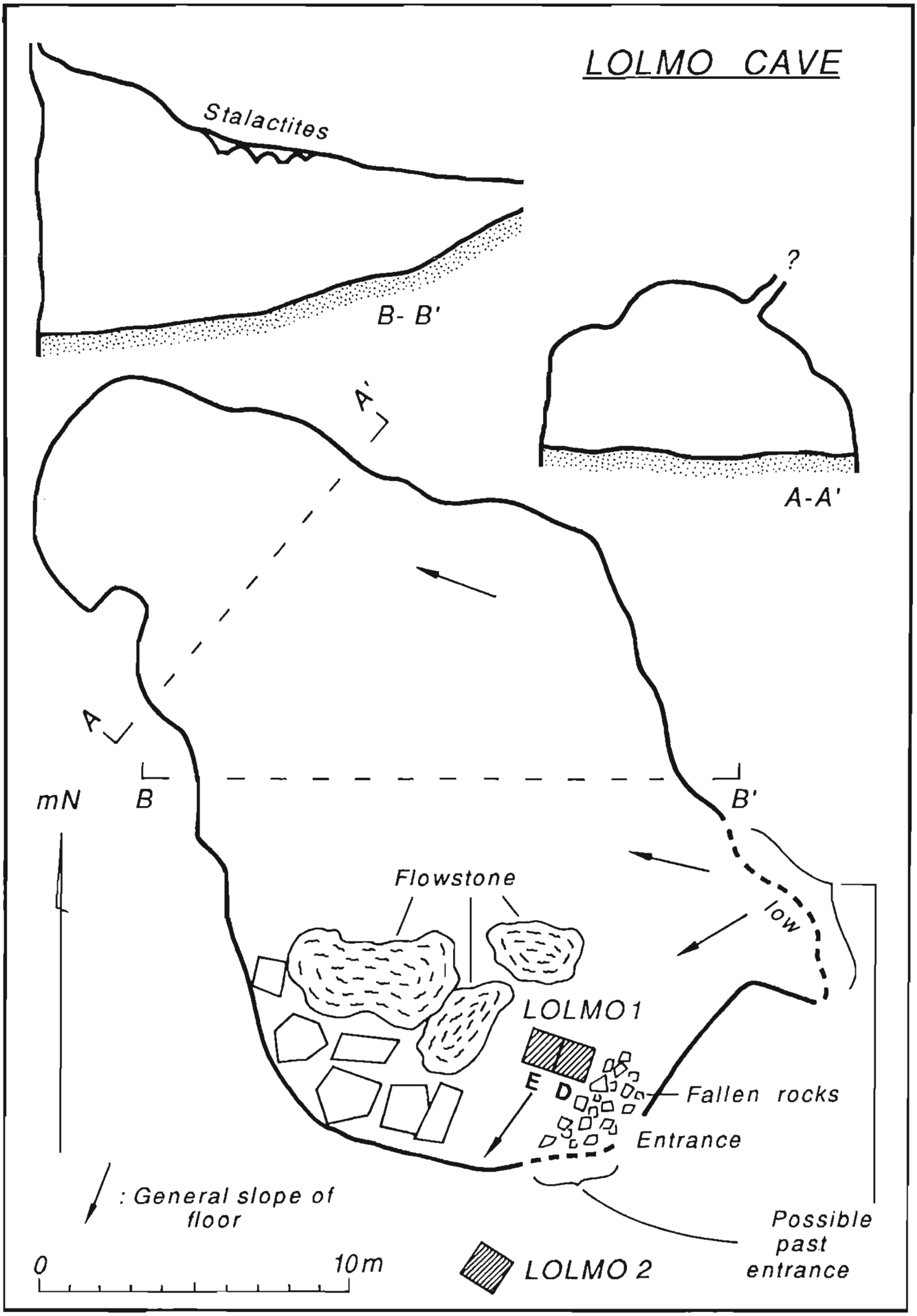

Fig. 3. A plan of Lolmo Cave showing the excavations.

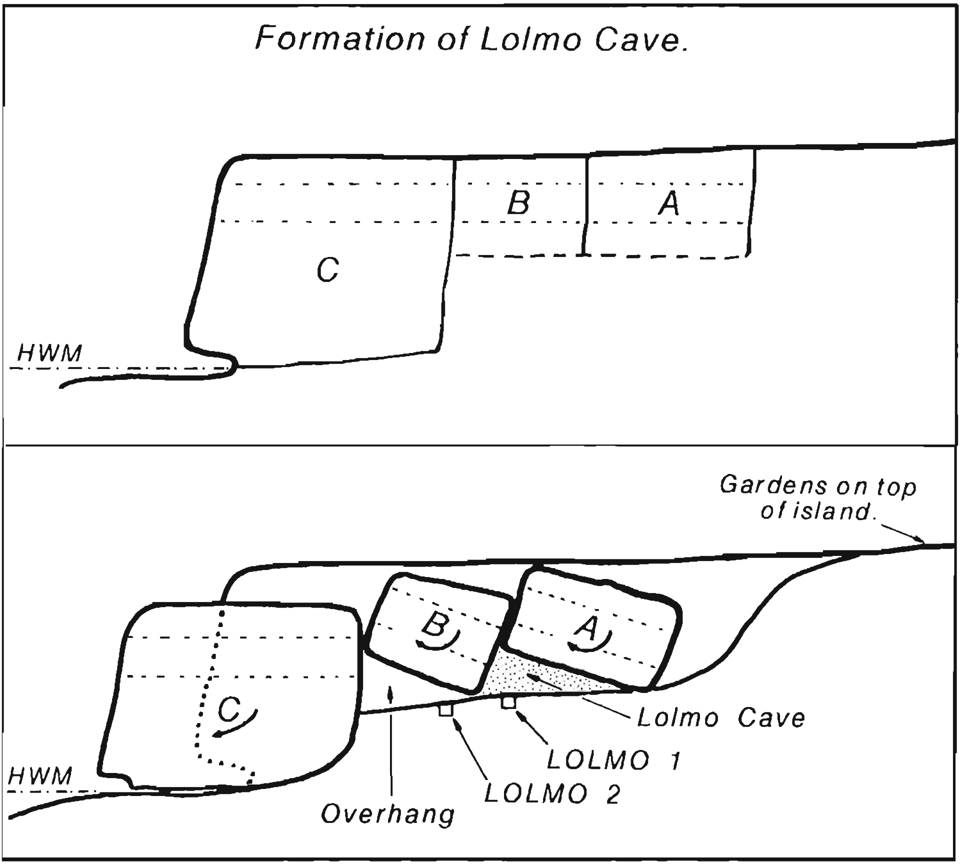

Fig. 4. The formation of Lolmo Cave.

of Lolmo are two of these joints, about 100 m apart. The limestone between the joints has slumped downslope, and the seaward block now projects 5 m beyond the cliffline on either side. As the limestone moved downslope, it split into blocks that rotated backward (Fig. 4), so the bedding in the blocks dips at 30–35° away from the coastline. The bedding in the limestone on either side of the slumped area is horizontal.

The backward rotation of two of these blocks opened up a cavity between them, forming Lolmo Cave (Fig. 4). The subvertical southwestern wall of the cave is the plane along which the blocks split, and the roof of the cave represents an original bedding plane in the limestone. The downslope movement of the limestone blocks formed a large gully; this opens directly onto the top of the island, which is fairly flat and covered by gardens. The backward rotation of the block that forms the roof of Lolmo has resulted in a depression just above the cave, at the head of the gully. Soil and other material that fell or was washed down the sides of this depression was funneled directly into the cave through the northern entrance, until this entrance was partially blocked by the buildup of material and rock fall.

The slumping that formed the cave was at least partially the result of undercutting at the base of the seacliff, where there is a notch undercut as much as 2 m in places. Notches at the base of coastal limestone cliffs form as a result of solution by seawater and the effects of various organisms, particularly algae and molluscs (Trudgill 1985). Along the southern side of Kumbun, the notch has incised even farther along the vertical joints, which have also been enlarged by solutional widening to form narrow open cracks.

The cave formed at least 6000 years ago, because the basal cave sediments gave a radiocarbon age of 5760 B.P. (see below). The slumping may have been triggered by undercutting of the cliff as sea level reached approximately its present height about 6000 years ago (Gosden and Webb in press). Alternatively, the cave may be older, because the slump could have been initiated by an earthquake; the south coast of New Britain is a seismically active area (Ryburn 1976).

EXCAVATIONS AT LOLMO

Stratigraphic Sequence

Lolmo is one of 13 sites excavated in the Arawe Islands, most of which date to Lapita and later periods (Gosden and Webb in press). The main aim of the Lolmo excavations was to provide dateable sequences encompassing both the Lapita and pre-Lapita periods, thus extending our knowledge of the area back into the mid-Holocene. Two areas were excavated, both in 10-cm spits. The first (Lolmo 1) was a 2 by 1 m trench (squares D and E) just inside the present-day entrance to the cave (Fig. 3). The second area (Lolmo 2) was outside the cave underneath an overhang, on a ledge overlooking the sea.

In Lolmo 1, the stratigraphic sequence recognized during the excavation is divided into five units (Fig. 5; Table 1 shows the dates of the various units). Unit 1 comprises the top 25 cm, which is a loose brown sediment containing recent material such as iron and glass. Unit 2 is similar to unit 1, but more compacted and with a greater clay content. It also contains modern material in its upper part, as well as pottery, obsidian, and bone. These two layers probably date to the time of World War II, when local people sheltered from bombing in the cave.

Unit 3 comprises dark brown (10YR 3/4) sediment with pottery, bone, and obsidian. Unit 4 is a compacted dark brown (10YR 3/4) soil with some purple concretions and large amounts of roof fall, especially toward the base of the unit.

TABLE 1. THE DATES FROM LOLMO AND THEIR STRATIGRAPHIC POSITION

					CALIBRATED AGE		
SITE	PROVENIENCE	MATERIAL	LAB. NO.	AGE B.P.	LOWER	INTERCEPT	UPPER
FOF Lolmo	Sq E, spit 5	*Tridacna*	Beta 26643	4320 ± 80	4535	4430	4363
FOF Lolmo	Sq E, spit 13	*Anadara*	Beta 26644	3530 ± 70	3473	3401	3343
FOF Lolmo	Sq E, spit 19	*Tridacna*	Beta 26645	4930 ± 80	5318	5272	5179
FOF Lolmo	Sq E, spit 26	Muridae sp.	Beta 26646	4210 ± 90	4414	4311	4166
FOF Lolmo	Sq E, spit 28	*Tridacna*	Beta 28223	5670 ± 100	6189	6083	5941

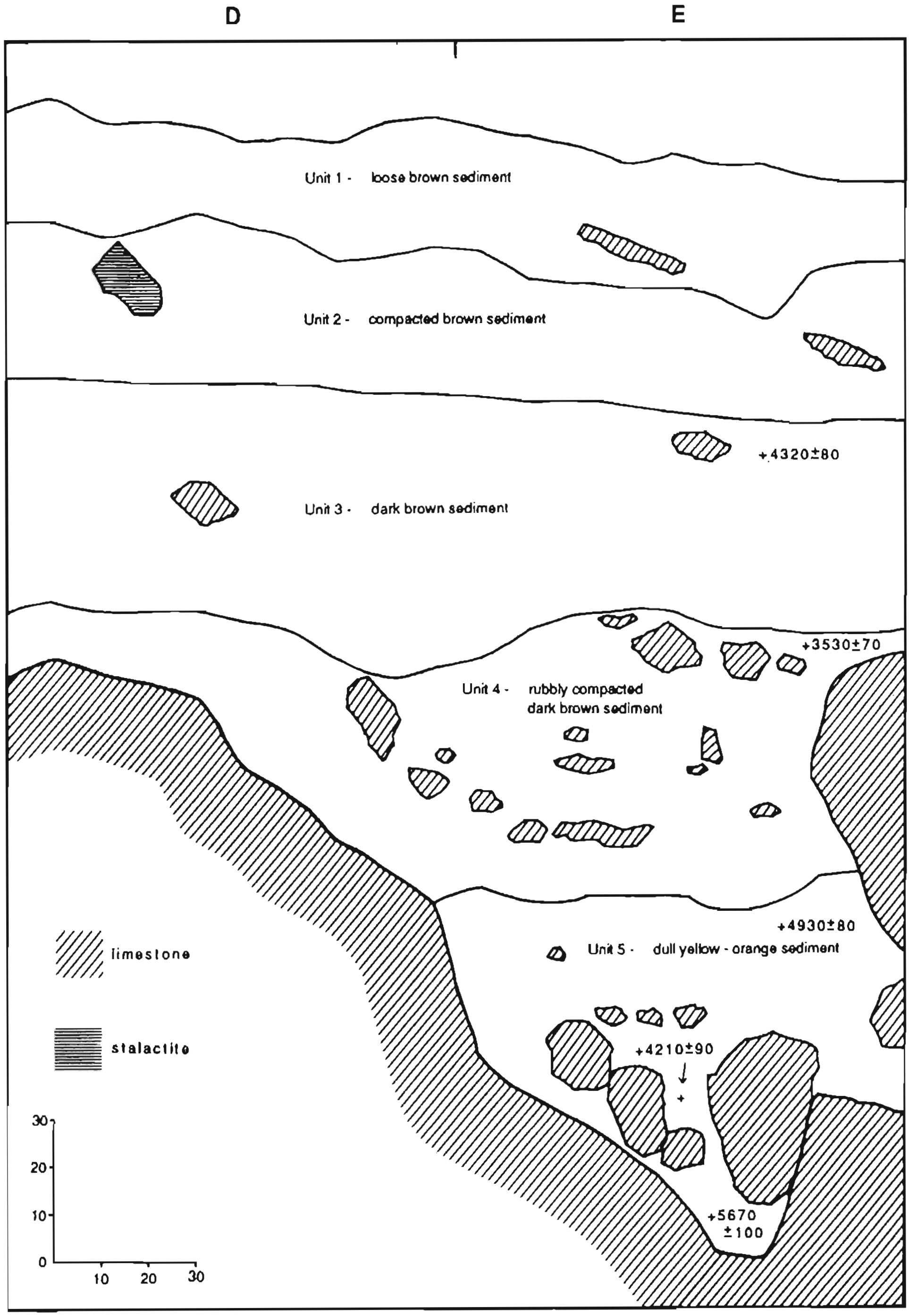

Fig. 5. The south section of Lolmo 1 showing the stratigraphic units and dates.

It contains pottery in its upper part (that is, down to 1.3 m from the surface) and obsidian, bone, worked shell, and shell throughout.

Two radiocarbon shell dates derive from units 2 and 4. The first comes from square E, spit 5 and dates to 4320 + 80 B.P. (uncalibrated, Beta 26643), and the second is from square E, spit 13 (3530 + 70 B.P., Beta 26644). The second of these dates fits well with the material with which it is associated (incised Lapita pottery being the main diagnostic [see below]). However, the first date is both too old for its association with Lapita pottery and out of sequence with the underlying date. The reasons for this inversion are unknown.

The basal layer (unit 5) is separated from unit 4 by a rapid gradation over less than 5 cm. It consists of dull yellow-orange (10YR 6/4) sediment with small amounts of obsidian, bone, shell, and worked shell (including a fishhook [Fig. 6]). This layer extends down to the base of the excavation in limestone boulders at spit 28. A tumble of roof fall was found at the base of the excavation in square D, near the entrance of the cave. The lower units were less well represented here than in square E, 1 m farther into the cave, which may have terminated in bedrock.

Three dates derive from unit 5: the uppermost is 4930 ± 80 B.P. (Beta 26645) from square E, spit 19; underlying this is a later date (4210 ± 90 B.P., Beta 26646) from square E, spit 26, with the lowest date (spit 28) being the oldest at 5670 + 100 B.P. (Beta 28223). These dates are not in sequence, and this introduces an element of uncertainty; however, the fact that they are all pre-Lapita and are found in aceramic layers leads us to believe that they are of the right order of magnitude. The problems of dating are discussed again in the section on obsidian sourcing.

In Lolmo 2, which reached a maximum depth of 1.6 m, only the lower two units in Lolmo 1 are represented. There is a thin upper disturbed layer, underlain by 30 cm of dark brown sediment belonging to unit 4. The dull yellow-orange sediment beneath this contains some obsidian, shell, and bone and has been assigned to unit 5. The Lolmo 2 excavation is only 6 m from Lolmo 1 (Fig. 3), but the two are separated by an extensive pile of rubble. The base of unit 5 in Lolmo 2 is at a lower level than in Lolmo 1 and may therefore be slightly older. However, no dates have been obtained from Lolmo 2, because of the small size of shell and charcoal samples found, reflecting the generally low amounts of artifact material in this excavation.

Composition and Origin of the Sediments

The sediments excavated at both sites are relatively uniform in composition throughout the sequence. The sand- and silt-sized fraction, which makes up the bulk of most samples, consists predominantly of translucent angular shards of volcanic glass, often clearly vesicular. Also present are abundant subspherical accretionary lapilli, composed of silt-sized glass shards; the lapilli are 1–2 mm across and often have a thin outer yellow shell around a darker orange-red nucleus. Small crystals of alkali feldspar and quartz occur occasionally, together with rare grains of pyroxene and amphibole.

All this material represents volcanic ash (tephra) deposited from a windblown eruption cloud onto the summit plateau of the island and then washed into the

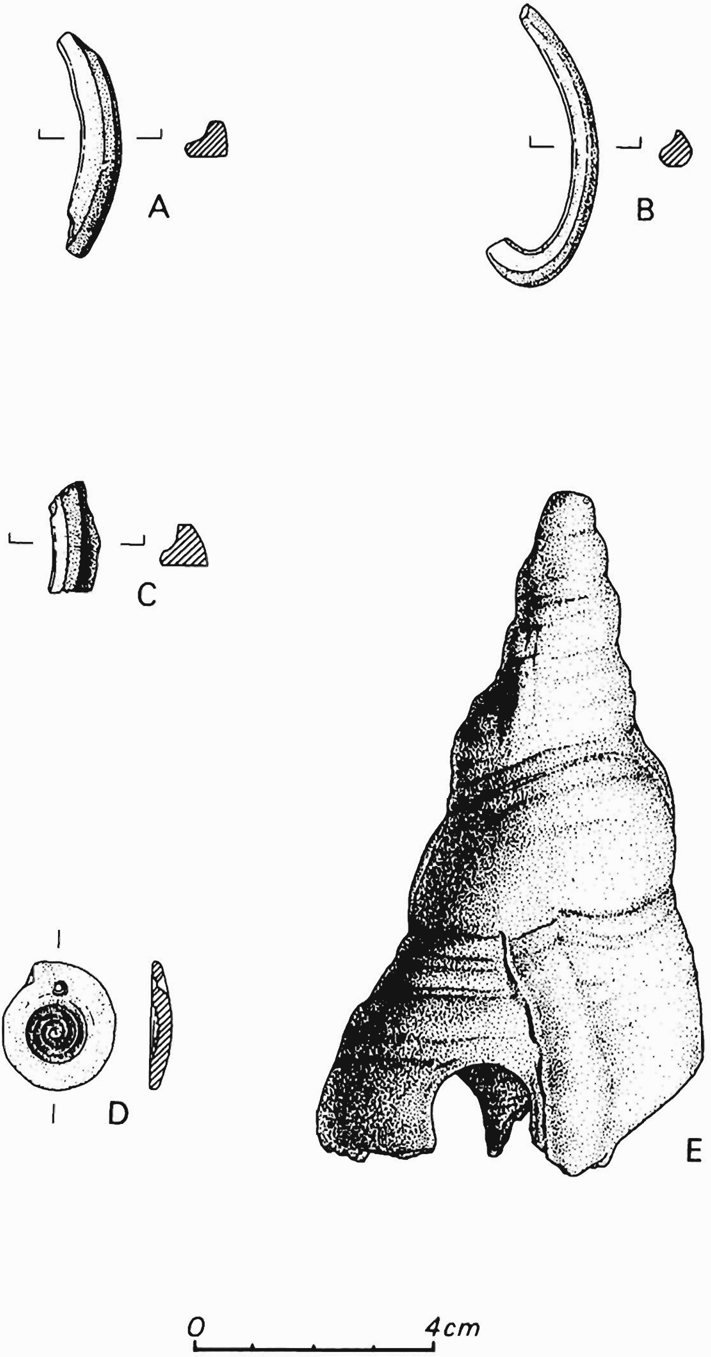

Fig. 6. The shell artifacts: *A*, square E, spit 24; *B*, square D, spit 19; *C*, square E, spit 14; *D*, square E, spit 22; *E*, square E, spit 22.

cave through the northeastern entrance. Two separate eruption events are represented, because the volcanic glass from unit 5 has a different refractive index (1.515–1.520) from the glass shards in layers 3 and 4 (1.505–1.510). The most likely source of the tephra is Witori Volcano adjacent to the Mopir obsidian source (Fullagar et al. 1991) on the north coast of New Britain (Fig. 1). This volcano has erupted five times in the last 6000 years, and tephra layers, probably from these eruptions, have been detected in archaeological excavations at several sites northeast of Kandrian (Pavlides 1993). Eruption WK2 occurred about 3300 years B.P., and glass from this eruption has a refractive index of 1.507–1.510 (H. Mashida, pers. comm.). Thus it is possible that layers 3 and 4 are composed of tephra from the WK2 eruption, based on the similarity in refractive indices; the radiocarbon age of 3530 + 70 B.P. from layer 4 is consistent with this hypothesis. The older eruption represented by unit 5 cannot, at present, be identified; its refractive index (1.515–1.520) does not match that of eruption WK1 (1.509–1.511), which occurred about 5630 B.P. (Pavlides 1993). The unit 5 tephra may be from a still-earlier eruption, such as those recorded from beneath the WK1 tephra in the Yombon excavations (Pavlides 1993).

The gravel-sized component of the cave sediment at Lolmo consists of artifactual material together with limestone blocks and fragments, derived largely from roof fall. In addition, many samples from Lolmo 1 contain irregular brown calcareous concretions, usually less than 1 cm across. These consist of volcanic ash and other material, including shell fragments, cemented by fine-grained calcite. Concretions are absent from the Lolmo 2 sediments, probably because of the dryness of that site. At Lolmo 1 the surface of the sediment is often damp, as a result of cave drips and water seeping in from the northeastern entrance.

The difference in color between the dark brown sediments of units 3 and 4 and the orange-brown sediments of unit 5 (in both Lolmo 1 and 2) is caused by differences in their small clay content (< 10%). This is dull yellow-orange (10YR 6/4) in the lowest unit but dark brown (10YR 3/4) and more abundant in units 3 and 4. The clay mineral present in both is allophane (identified by infrared absorption). Allophane is a general term for noncrystalline hydrous aluminosilicates of variable composition (Russell 1987) and commonly forms as an alteration product of volcanic ash (Wada 1980). The difference in color may be a result of the amount of weathering that the volcanic ash has undergone. The dark brown (7.5YR 3/4) soil on top of the island above the cave consists of over 40 percent dark brown allophane, with occasional crystals of quartz and feldspar and abundant organic matter. Identifiable volcanic glass shards are absent, having been transformed entirely to allophane by rapid weathering in the tropical climate. The presence of relatively fresh volcanic glass in the cave sediments reflects the fact that the cave floor is largely protected from weathering by being kept quite dry, particularly in the case of Lolmo 2. The darker brown sediments of units 3 and 4 are more weathered than those of unit 5 and are therefore darker in color.

The volcanic ash that accumulated within the cave must have been blown in and/or washed in through the northeastern entrance. Immediately after each eruption, when tephra blanketed the landscape and much of the forest may have been killed, volcanic ash could easily have been washed into the cave. However, in tropical climates the vegetation quickly reestablishes itself (e.g., 8 years after the eruption of Vulcan in eastern New Britain the cone was completely covered in vegetation [Johnson and Threlfall 1985]). The vegetation stabilizes the surface sediment and prevents soil erosion, so only directly after an eruption should there have been an influx of relatively unweathered tephra into the cave. The deposition of unit 5 appears to fit this hypothesis closely.

However, compared with unit 5, the tephra of units 3 and 4 is thicker and more weathered. It is uncertain whether units 3 and 4 were weathered *in situ* within the cave or whether the sediments composing these units were partially weathered on the surface of the island and then washed into the cave. The sharp boundary between units 4 and 5 in Lolmo 1 (*in situ* weathering normally produces a gradational boundary) and the fact that units 4 and 5 represent different eruptions suggest that the latter hypothesis is more plausible. In this case, the top of the island may have been cultivated at the time that unit 4 was deposited, so the soil erosion associated with clearing of gardens could have released the partially weathered tephra that was washed into the cave. On the beach sites excavated elsewhere in the Arawes there is evidence of the erosion of clay from the upper parts of the islands during the Lapita, probably resulting from the clearance of vegetation for cultivation (Gosden and Webb in press). The greater thickness of units 3 and 4 (compared with unit 5) could also indicate this. The relative lack of weathered clay in unit 5 might then imply a lower intensity or absence of gardening during deposition of this unit (i.e., in the pre-Lapita period).

There has been little sediment accumulation within the cave between c. 3000 years B.P. and the present. The northeastern entrance, which would have been the main pathway for sediment influx, must have been almost completely blocked around 3000 years ago, by sediment buildup and rockfall.

MATERIAL CULTURE

Three main sets of artifactual evidence were recovered: pottery, worked shell, and obsidian. The distribution of these materials, plus that of food shell, through the stratigraphic units is given in Table 2. We will treat each class of material separately.

Obsidian

One of the objectives of work in West New Britain over the last 5 years has been to look at the movement of obsidian in all periods from the Pleistocene to the present. Lolmo is the only site from the Arawe Islands with a pre-Lapita phase.

TABLE 2. THE MATERIAL FROM LOLMO 1 AND ITS STRATIGRAPHIC POSITION

	POT NO.	POT WT (g)	OBSIDIAN NO.	OBSIDIAN WT (g)	SHELL NO.	SHELL WT (g)
Unit 1	13	40.9	108	70.5	1299	2826
Unit 2	18	46.9	43	20.6	289	1440
Unit 3	51	114.8	69	30.7	144	765
Unit 4	33	65.8	259	141.4	2064	5147
Unit 5	0	0	148	84.5	2084	9498
Total	115	268.4	627	347.7	5844	19686

Consequently, a major objective of the Lolmo sourcing study was to assess the nature of obsidian movement and its changes from the mid to late Holocene, particularly because obsidian represents the most numerous class of find in the site, with 627 pieces being recovered. Given the uncertain chronological control on the deposits at Lolmo, we shall consider the data on obsidian sourcing first, because this, when considered against the broader pattern of obsidian movement throughout the Bismarck Archipelago, throws light on the dating of the Lolmo sequence.

Two sets of obsidian sources are known within New Britain, Talasea and Mopir (Fig. 1); in the Talasea region there are several sources, Kutau/Bao being the most important. Obsidian from the different sources can be distinguished geochemically (using the PIXE-PIGME technique [see Summerhayes et al. in press for full details]). As part of a larger project, aimed at "comparing and contrasting the extent to which obsidian has played a significant role in prehistoric social and economic behavior in the Talasea, Kandrian and Arawe regions" (Summerhayes et al. in press), over 1000 source and archaeological obsidian samples have been analyzed. The results of that study indicate that both Mopir and Talasea sources were exploited from the late Pleistocene through to the middle Holocene. From the beginning of the Lapita period (≈3500 years B.P.), the Talasea sources predominate and Mopir obsidian is absent, being found again only in deposits from the last thousand years. The most likely reason for the switch from the Mopir to the Talasea sources is the major WK2 eruption of the Witori Volcano adjacent to Mopir, at about 3300 years B.P. The great thickness of ash from this eruption could easily have covered the Mopir obsidian flows for a considerable period of time (Summerhayes et al. in press).

Forty-four samples of obsidian from Lolmo 1 were analyzed geochemically, to match their chemistry with that of known sources. Because we were attempting to understand changes in source use over time, an effort was made to select samples from throughout the sequence at Lolmo (Table 3). The selection of samples was partially constrained by size, but samples were selected so that we could compare obsidian from preceramic and ceramic layers. The top two stratigraphic units were also excluded, because these date from the occupation of the cave during World War II.

The results (Table 3) show that the majority of samples (80 percent) were derived from the Kutau/Bao source in the Talasea area, and 14 percent came from Mopir. Three samples fell outside known sources. Both Mopir and Kutau/Bao

TABLE 3. THE STRATIGRAPHIC POSITION OF OBSIDIAN SAMPLES AND THEIR ATTRIBUTION TO SOURCES

	SQUARE D	SQUARE E	KUTAU/BAO	MOPIR	UNKNOWN
Unit 1	0	0			
Unit 2	0	0			
Unit 3	5	2	6	1	
Unit 4	9	11	15	2	3
Unit 5	2	15	14	3	0
Total	16	28	35	6	3

obsidian are found in unit 5 and the basal part of unit 4, but with the introduction of pottery in unit 4, Mopir obsidian disappears and does not recur again until the late prehistoric period. The samples involved here are small, but the pattern is clear. The lack of Mopir obsidian in Lapita-age strata has been confirmed from three Lapita period sites in the Arawe region (Paligmete [FNY], Apalo [FOJ], and Adwe [FOH] [Summerhayes and Hotchkis 1992]). The pattern of source distribution in Lolmo helps to confirm that unit 5 and the basal part of unit 4 can be assigned to the pre-Lapita period, confirming the radiocarbon dates in unit 5. The upper part of unit 4 belongs to the Lapita period, confirming the radiocarbon date from this horizon, as does the analysis of the tephra composing this unit.

With regard to the technological features of the obsidian assemblage from Lolmo, although the sources from which obsidian derived changed through time, there is no evidence that the technology used to reduce obsidian altered significantly over 6000 years. This may have more to do with the limited range of activities carried out in the cave rather than a reflection of overall stability of technology, because there is good evidence of change elsewhere on New Britain over this time period (Pavlides 1993; Torrence 1992). Obsidian was found throughout the deposits at Lolmo (Table 2). The majority of pieces are less than 40 mm in maximum dimension, and this small size is a feature of the assemblage throughout the period of occupation. The most notable change is not in the nature of reduction of obsidian, but in the amounts in which it is found. Most obsidian is found in units 1 and 4 (195.8 g/m^3 and 220.6 g/m^3, respectively), correlating with the introduction of pottery, and this may indicate either an increase in the use of the cave at that time or an increase in the supply of obsidian. The least obsidian is found in units 2 and 3 (44.9 g/m^3 and 47.9 g/m^3, respectively), indicating again either a change in the use of the cave or restriction in the supply of obsidian. More bipolar cores are found in unit 4 than in any other layer, and this may provide some tentative evidence that obsidian was being worked down further at this period compared with both before and after. The lack of cortex through all units indicates that we are dealing with late stages of the reduction sequence in all periods.

Very little nonobsidian flaked stone was recovered from Lolmo, and this comprised mainly chert and volcanic rocks of unknown origin. As well as flaked stone, we found considerable numbers of river cobbles from the mainland, which were used as oven stones, indicating that fires were regularly lit in the cave in all periods of its occupation.

Pottery

Pottery was found from the top of the site down to spit 15, which is within stratigraphic unit 4. No pottery was found in the base of unit 4 or unit 5. Spit 13, square E has a date of 3530 ± 70 B.P., which indicates that the pottery comes in at the beginning of the Lapita period. There is consequently a lack of coincidence between the change in stratigraphy between units 4 and 5 and the introduction of pottery. This is not surprising because both sediments and material culture are responding to different sets of causes and effects: the sediments are entering the cave as a result of the fall of tephras and clearance on the top of the island; pottery is adopted for reasons that are yet unclear. Only 11 of the 115 sherds were decorated (five from square D and six from square E). Seven of these had fingernail impressions, and two were incised with two notched rims. All of these fit within the range of late Lapita pottery types, although it is interesting to note that no dentate stamping was found even though this is common on the contemporary beach site at Apalo, also on Kumbun Island (Gosden and Webb in press).

A similar pattern has been found in Lapita-period sites in the Mussau group, where most caves and shelters yielded small amounts of pottery, most of which was undecorated and especially lacking in dentate stamped sherds (Kirch et al. 1991:149–151). The Nissan sites that have usage during the Lapita period also have small numbers of sherds, with little dentate stamped decoration (Spriggs 1991*a*:plate 2). It may well be that large amounts of pottery with a high percentage of dentate stamping are only found on sites that formed the main areas of habitation. The one site of this type that may provide evidence of more permanent occupation is the EKQ shelter in Mussau. It produced large quantities of pottery, including dentate stamped sherds, which were more frequent in the base of the deposit, giving way to incised sherds in the upper layers (Kirch et al. 1991:151, fig. 4). We will take this point up again below in discussing the type of site that Lolmo might represent.

Worked Shell

Seven pieces of worked shell were recovered from Lolmo (Fig. 6). Of these, five came from the pre-Lapita levels. The existence of worked shell in pre-Lapita levels is significant because it has been thought that shell technologies only came into being with the introduction of Lapita pottery and may thus represent an intrusive element. The pre-Lapita worked shell includes a flake of *Tridacna gigas*, a *Tridacna* sp. ring, a *Conus* sp. disk with a perforation, a broken piece of fishhook made of *Trochus niloticus*, and a *Charonia tritonis* shell with a bored hole. In the levels in which Lapita pottery occurs, there is one piece of flaked *Tridacna gigas*, and in unit 3 there is an armband fragment. It is possible that the artifactual shell was produced in the Lapita period and moved down through the deposits into the pre-Lapita levels at Lolmo. However, the fact that pottery is found only in the upper part of the site and not in the lower shows that there has not been mass movement of material, as is also demonstrated by the patterning of obsidian from different sources. Furthermore, most of the worked shell is found in the lowest units (five out of seven pieces), and only one flake is found in Lapita layers. Therefore, despite the chronological uncertainties of the site, we are confident that Lolmo supplies evidence of pre-Lapita shell working.

All the worked shell from the pre-Lapita levels fits within the artifactual shell assemblages found in the Arawe Islands Lapita sites (Smith 1991), and we take this as evidence of continuity in production of shell artifacts between the pre-Lapita and Lapita phases. The lack of worked shell assemblages from periods before 3500 B.P. hitherto can be seen as due to the lack of sites from the mid-Holocene period. Both Green (1991) and Spriggs (1991*b*) noted the occurrence of pre-Lapita shell technologies in a number of sites in the Bismarcks. Shell types include *Tridacne* adzes in the Pamwak site on Manus perhaps as early as 10,000

B.P., shell beads in pre-Lapita contexts in New Ireland and Guadalcanal, and *Trochus* armbands and fishhooks in Guadalcanal and Pamwak in pre-Lapita contexts. When more sites from the relevant periods are found, we predict that worked shell will be found dating to the mid-Holocene and before.

It can be seen from Table 2 that the greatest amount of food shell is found in the lowest two units. The shell is predominantly of reef species and was presumably gathered from the reef at the base of the cliff below the cave. The amount of shell deposited in unit 5 provides an exception to the generally low levels of material found in that unit.

FAUNA

Vertebrate faunal remains were recovered from Lolmo 1 and 2, but these are very sparse and, unlike the obsidian or pottery, show little chronological patterning. Most are small fragments of postcranial elements, and those belonging to the larger animals are poorly preserved. There were few diagnostic pieces, and for many species identifications are tentative.

Lolmo 1 yielded 1063 skeletal remains (Table 4), weighing a mere 125.7 g. The assemblage is unevenly distributed, with well over half being found in stratigraphic units 4 and 5; unit 3 contains the least amount.

Lolmo 2 only produced 288 pieces of bone, over 50 percent of which was found in unit 1 (Table 5). It contained a range of fauna similar to that in Lolmo 1.

Large Mammals

A single human molar was recovered from the top levels of Lolmo 1. As is the case in cave deposits elsewhere in New Guinea (Baldwin 1990; Marshall and Allen 1991), pig remains (*Sus scrofa*) are uncommon, being represented by two isolated teeth only. The first is a molar found in Lolmo 1 above the date of 3530 ± 70 B.P., which places it well within the Lapita period. A single incisor was recovered from the surface of Lolmo 2 and is probably recent in age.

TABLE 4. THE BONE (NISP) FROM LOLMO 1

	UNIT											
	1		*2*		*3*		*4*		*5*		TOTAL	TOTAL
BONE	NO.	WT.	NO.	WT.	NO.	WT.	NO.	WT.	NO.	WT.	NO.	WT.
Human	1	0.3									1	0.3
Pig							1	2.5			1	2.5
Chiroptera (bat)	4	0.3	7	1.0	6	2.7	9	1.4	26	3.5	52	8.9
Muridae (rat)	1	0.1	1	0.1					2	0.6	4	0.8
Lizard	1	0.1			2	0.9					3	1
Snake	2	0.7	1	0.1	1	0.1	3	0.2			7	0.8
Frog	5	0.2	2	0.2	2	0.2	0	0.0	3	0.2	12	0.8
Fish	249	23	88	6.2	44	5	213	25	223	20	817	78.6
Unidentified	14	4.0	11	0.9	27	7.3	64	9.3	50	11	166	32
Total	277	28	110	8.5	82	16.2	290	38	304	35	1063	125.7

TABLE 5. THE BONE (NISP) FROM LOLMO 2

	UNIT									
	1		2		3		4		TOTAL	TOTAL
BONE	NO.	WT.	NO.	WT.	NO.	WT.	NO.	WT.	NO.	WT.
Pig	1	0.1							1	0.1
Chiroptera (bat)	1	0.1			3	0.3	29	1.6	33	2
Muridae (rat)					1	0.2	4	0.2	5	0.4
Lizard	2	0.5							2	0.5
Snake					1	0.2			1	0.2
Frogs	3	0.3							3	0.3
Fish	140	16	9	2	1	0.1	5	0.2	155	18
Unidentified bone	40	6.1	8	5.8	8	0.6	32	1.5	88	14
Total	187	23	17	7.8	14	1.4	70	3.5	288	36

Rats and Bats

All rodent bones occur in the first three spits of Lolmo 1 and are therefore probably recent in age. Rodents are represented by at least two species: a small *Rattus*, probably the Pacific Rat (*Rattus exulans*), and the much larger *Uromys* sp., which occurs as a distally broken lower incisor. The Pacific Rat is present as a mandible that lacks all but its third molar. A small humerus that is complete except for its proximal epiphysis was found in an adjacent spit and probably also belongs to this species if not the same animal.

Bats usually occur as long bone fragments, although some teeth and mandible fragments are also present. At least two species, both Megachiroptera, are represented: a small *Hipposideros* and a larger taxon comparable in size with *Dobsonia*. The latter includes a large proximal long-bone fragment that is calcined, the best evidence for human consumption of bats at the site.

Reptiles

These consist of varanid, lizard, and snake remains, mostly vertebrae, in small numbers. The lizard remains include a large Skink or agamid.

Fish

Fish are the most abundant taxa in both assemblages (77 percent of Lolmo 1 and 54 percent of Lolmo 2). They are present throughout the two deposits and are abundant in the top spits. Fish occur as a range of elements, particularly vertebrae, spines, and teeth. Although unidentified, it is clear that most derive from small taxa and that several species are represented. They are obvious indications of human action in the cave.

Unidentified Bone

This includes "large mammal" long-bone fragments that are commonly burnt and probably derive from either pig or human. Several other pieces may be turtle carapace, but they are highly worn.

Both deposits also produced echinoid (sea-urchin) spines and the claws of Crustacea.

INTERPRETATION OF THE FAUNA

Like other limestone caves, the Lolmo site provides optimal conditions for the accumulation and preservation of skeletal remains from a variety of cultural and noncultural sources. For Lolmo 1 much of the assemblage was found toward the base of the deposit and includes many small and fragile skeletal elements. This suggests that the paucity of remains is not simply due to poor preservation but probably reflects a lack of deposition.

The Lolmo vertebrate fauna consists of a very limited range of taxa. The Chiroptera inhabit caves and hence at least most of their remains are probably a consequence of resident animals dying in the cave. This is also a likely source of some of the rodents, small lizards, and frogs. Others, such as the fish, larger reptiles, and the pig, are clearly cultural in origin and represent local procurement. However, the cave is poor in bone, both in the amount of bone and the taxa represented when compared with the sites on New Ireland, such as Matenkupkum and Panakiwuk (Gosden and Robertson 1991; Marshall and Allen 1991). For instance, in Panakiwuk 27 taxa are represented compared with seven in Lolmo, and the New Ireland site contains many more bones of large meat-bearing mammals, such as *Thylogale brunii* and *Phalanger orientalis* (Marshall and Allen 1991: table 13). Also, the amounts of bone per volume of deposit are quite different in Lolmo and Panakiwuk. The overall density of bone in Lolmo 1 is 541.7 g/m^3, which is equivalent to the lowest density of bone in Panakiwuk (502 g/m^3) in Unit D and well below the maximum for that site of 9517 g/m^3 in Unit B (Marshall and Allen 1991: table 10).

A further contrast is in the vertebrate assemblages from the open Lapita sites on the beaches elsewhere on Kumbun Island and on other islands in the Arawes. These beach sites represent shorter time durations and depositional contexts that are not favorable for the preservation of skeletal remains. They contain, however, sizeable quantities of large terrestrial species such as possum, wallaby, and cassowary, as well as large sea mammals. The Lolmo site fails to include these and other economically important animal resources known to be consumed elsewhere during Lapita times.

The absence of such fauna suggests that in contrast to the open sites, Lolmo Cave was utilized as a short-term refuge. It was never a major habitation site or a focus for recurrent economic activity, which may produce larger quantities of skeletal and invertebrate remains. As a point in a regional settlement strategy involving the island and the New Britain mainland, the Lolmo site was probably always peripheral, acting as a short-term shelter from the pre-Lapita period through to the present.

DISCUSSION

Our conclusions about Lolmo flow, at least in part, from the discussion of the fauna. There is no evidence from any aspect of the material found in the cave that Lolmo was ever central to the forms of settlement found on Kumbun Island over the last 6000 years. It seems most likely that the only intensive habitation of

Lolmo occurred during World War II, when people from all over the Arawe Islands sheltered in the cave.

One of the major points we are trying to pursue using the evidence from Lolmo is the nature of continuity and change between the pre-Lapita and Lapita periods. However, we also feel it necessary to establish that in comparing sites from different periods we are comparing like with like.

Lolmo is a site that contains a particular structure of evidence within it and may well fall into a class of sites from different areas around the Bismarck Archipelago. This class of sites comprises caves and shelters with relatively ephemeral, but long-term occupations that are located on small islands. Some of these caves have initial occupation dates between 6000 and 5000 B.P., when the sea reached at least its present level. The major set of shelters dating to this period come from Nissan (Fig. 1), and data from these are presented by Spriggs (1991*a*). Site DFV on Nissan has pre-Lapita occupation, with a greater number of shelters occupied during the Lapita phase (DFF, DGD/2, and DES). The sites also have a greater amount of material present in them during the Lapita phase than is found in previous periods (Spriggs 1991*a*: table 4). A comparison is made between the Nissan sites and Lolmo in terms of the density of material in the sites (Table 6) that shows relatively low levels of both obsidian and pottery. The smaller amounts of both pottery and obsidian in the Nissan sites compared with Lolmo may indicate that Nissan was farther outside the networks of connections operating in the Bismarcks than was the Arawe area. A further set of shelters is found in the Mussau group (Kirch et al. 1991), and these all date from the Lapita period or later (Kirch et al. 1991: table 2). No data are as yet available as to the densities of material in these shelters, but most of these seem to have low levels of material in them, with the exception of the EKQ site.

The pattern of occupation in these caves and shelters on small islands contrasts strongly with those found in two other sets of sites. The first of these are the caves and rockshelters found on New Ireland. As mentioned above, a series of caves and shelters exists, the occupation of which starts in the late Pleistocene and which contain large numbers of artifacts, bones, and shells (Gosden and Robertson 1991; Marshall and Allen 1991; White et al. 1991). However, in the mid-Holocene all these sites, with the possible exception of Balof, show evi-

TABLE 6. A COMPARISON OF AMOUNTS OF MATERIAL IN LOLMO AND THE NISSAN SHELTERS

SITE	UNIT/PHASE	POTTERY (g/m^3)	OBSIDIAN (g/m^3)
Lolmo	1	113.6	195.8
	2	47.4	44.9
	3	179.4	47.9
	4	91.4	220.6
	5	0	109
Nissan sites			
DFV	Takaroi	0	31.3
DFF	Lapita	29.4	10.4
DGW	Halika	0	1
DGD/2	Lapita	28.7	6.3

dence of a break in occupation. Occupation stops around 6000 B.P. and does not occur again until the last 1600 years. The other set of sites are beach sites, such as those on Mussau (Kirch et al. 1991) and the Arawes (Gosden 1991), which, especially when waterlogged, contain a wide range of materials in large amounts. Gosden (1991) provided a comparison of Lolmo and the beach sites of the Arawe Islands.

What can these different classes of sites tell us about the nature of continuities and changes between the pre-Lapita and Lapita periods? Generally, discussions of the similarities and differences in the periods before and after 3500 B.P. have been in general terms, without taking site type into account. For instance, Spriggs (1993:192–193) listed the major changes that occur with the advent of the Lapita period, which can be summarized as follows: the introduction of pottery; the first real evidence of farming, as shown by plant macrofossils and the pig, dog, and chicken; large stilt villages over reefs; stone adzes, a greater range of shell artifacts; an extension of settlement both south and east of the Solomons; and obsidian distributions. Our aim here is not to deny that the Lapita period represents major changes, but to make the point that we can only start to understand what changes Lapita does represent if we take into account the nature of the sites in which the evidence is found. The creation of modern beaches took place with the stabilization of sea level around 4000 years ago (that is, just before the Lapita period). The lower levels of these beaches remain waterlogged today and represent a set of unparalleled conditions of preservation for bone, plant remains, and shell. Many of the best-known Lapita sites are found in the bases of these beaches. Part of the discontinuities Spriggs saw as occurring with the Lapita period may derive from these new conditions of preservation. Plant remains, bone, and shell occur in large amounts in waterlogged Lapita sites, such as those in Mussau or in the Arawes, and this apparent discontinuity in the nature of the evidence owes as much to new taphonomic conditions as it does to changes in prehistoric ways of life. Many of the individual components of the shell and plant assemblages are found in pre-Lapita sites, but never in the range and numbers in which they occur in beach sites; this may be purely due to taphonomic conditions and sample size differences. Spriggs also maintained that the existence of large stilt villages over reefs is new, but this cannot be demonstrated because we have no evidence of settlement along the shoreline before the Lapita period, as these older shorelines have been drowned by the rising sea level.

Establishing continuities before and after Lapita is thus made more difficult by changing site structures and formation processes. On the one hand we have the long-term history provided by the New Ireland caves and shelters, which are on a large continental island and sampling particular ways of life and sorts of materials. These generally have a gap in their use between the mid- and late Holocene. On the other hand we have the large rich sites on newly formed beaches from the Lapita period onward. One set of sites that bridges the gap between the pre-Lapita and Lapita periods are the caves and shelters on small islands. These, however, are not directly comparable in amount or range of materials with the New Ireland caves or the Lapita beach sites. To judge continuity and discontinuity, we have to ensure that we are comparing sites of like type. It must be said parenthetically that help is at hand in evaluating these issues of change in the form of a series of sites in the Talasea area on northern New Britain, particularly on Garua Island, that have evidence from both the pre-Lapita and Lapita periods (Specht et al. 1991) and also in the interior of New Britain at Yombon (Pavlides 1993). Further publication of material from these sites will allow us to evaluate changes in material in sites with the same sorts of formation processes operating across the pre-Lapita/Lapita boundary.

Bearing these points in mind, what can Lolmo tell us about the nature of change from the mid- to late Holocene? First of all, it may well be significant that Lolmo was first occupied 6000 years ago when the sea was rising toward its present level. At that time the area we now know as Kumbun was changing from a hill to an island, and this change may have brought with it changes in the use of the landscape. The only direct evidence we have of this change within the Arawe area is the occupation of Lolmo. Worked shell is found in the pre-Lapita phases, and the small assemblage we have looks very similar to the Lapita-period shell assemblages we have from beach sites in the Arawes. Obsidian source use does change, but only in a minor way, with most obsidian in all periods coming from the Kutau/Bao source. The stability of source use is paralleled by a lack of obvious change in the nature of reduction of obsidian. Neither bone nor shell assemblages show marked changes, although more bone was deposited in the Lapita period than earlier. The major change was the introduction of pottery, which is totally absent from the lowest level.

What we can say from the Lolmo evidence is that there is both change and continuity, which reflect on our appreciation of broader changes in the western Pacific. One of the major implications of our final discussion is that Lapita is not so much a period, or perhaps even a social form, but a type of site created in the beaches formed by the mid-Holocene sea level rise. Lapita beach sites may well be comparable with each other because of the similarity of formation processes, both human and natural. Nonbeach sites such as Lolmo are difficult to compare directly, having a different structure of evidence within them. It is only when various structures and formation processes are appreciated that controlled comparisons can be made between place and period.

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ABSTRACT

Lolmo Cave on Kumbun Island in the Arawe Island group off the south coast of New Britain, Papua New Guinea, was occupied between 6000 B.P. and the present. It is therefore one of a small number of sites that spans the pre-Lapita, Lapita, and post-Lapita periods. The chronology of the cave derives partly from tephras from dated eruptions on the north coast of New Britain. The evidence from the cave shows elements of continuity between all three periods in the use of obsidian from Talasea sources and in the production of shell artifacts. The main change in material culture is in the introduction of pottery and the use of Mopir obsidian in the pre- and post-Lapita periods, but not in between. The bone assemblages indicate ephemeral use of the cave in all periods, as does the generally low level of artifact deposition. The first occupation of Lolmo 6000 years ago coincides with changes in the nature of the evidence elsewhere in the Bismarck Archipelago. Taken together, these sites provide evidence for continuity between the pre-Lapita and Lapita periods, providing empirical contradiction to the notion that Lapita assemblages represent the incursion of people from the west and thus a break with the past. KEYWORDS: Lapita, pre-Lapita, Melanesia, formation processes, continuity.