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Anthropology

NEW SERIES, NO. 42

Exploring Prehistory on the Sepik Coast of Papua New Guinea

Editors,
John Edward Terrell
Esther M. Schechter

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Cover photograph: Rob Welsch and Helen Naway at Sapi Village on Tumleo Island, 1990.
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In memory of Baiva Ivuyo, Robert Mondol, and
those killed at Sissano Lagoon on 17 July 1998

Prologue

Shortly after dusk on Friday, 17 July 1998, while people were settling down to eat dinner, three seismic sea waves caused by a relatively minor local earthquake measuring 7.1 on the moment magnitude scale battered Sissano Lagoon on the Sepik coast of Papua New Guinea. Reportedly, the coming ashore of these massive waves sounded like a jet airplane taking off. Their destruction was staggering. Debris later found hanging from the tops of palm trees showed that the waves had reached heights of over 14 m. The precise human death toll may never be known. It is thought that somewhere between 2,000 and 3,000 men, women, and children were killed instantly, swept out to sea, or maimed in just a few minutes time. Approximately 9,000 people were left homeless. The communities at Malol, Arop, Warapu, and Sissano were totally destroyed or extensively damaged. Arop and Warapu, which were located on the narrow strip of sand and beach that divides Sissano Lagoon from the sea, each lost roughly one-third of their inhabitants. The first sea wave scoured these villages clean; the other two huge waves covered what was left with sand.

Foreword

We report here on field and laboratory investigations conducted on the north coast of Papua New Guinea under the aegis of the Field Museum of Natural History that began in 1990 in the coastal area comprising the 350 km of shoreline between the Indonesian border in the west and the small coastal village of Kaiep (or Kep) in the east. We also draw on additional information gleaned from the ethnographic material culture collections housed at the Museum purchased locally by Field Museum curators and others a century ago at villages on the 710 km of coast between the international border with Indonesia and Madang.

This research has been motivated by several complementary issues in anthropology and museum studies. Among these, four have been most influential in shaping our choice of research goals and strategies. How isolated or in touch with one another were communities on this coast in the past? How culturally distinct were these communities? How isolated had this coast been from contact with other places elsewhere in the southwest Pacific in prehistoric times? Finally, as we like to colloquially phrase the concern, can anthropologists do good anthropology with the Museum's famous ethnographic collections from this part of the world?

In the course of our investigations, we found an impressive diversity of previously unknown and unrecorded prehistoric pottery styles, both locally in the Aitape area and elsewhere along the entire coastal area surveyed in 1993–1994. In the Serra and Aitape localities, it was also possible to use the evidence recovered in different locales to develop tentative local ceramic sequences.

It is now possible to argue that all the ceramic industries, extant and prehistoric, on the coast from Aitape to Jayapura in Papua, Indonesia—described archaeologically for the first time in this monograph—are alike derived historically from the same red-slip tradition, which on present evidence was first established on Tumleo, for example, around 2,000 years ago.

Nothing that we have been able to piece together so far about life on this coast over the past 2,000 years or so hints that major displacements and relocations have been influential on the Sepik coast, which is not to say that moving around from place to place for various reasons has never happened locally. Our obsidian and ceramic sourcing studies have contributed evidence suggesting that communities on the coast and on the nearby islands have long been in contact with—and therefore open to influences from—other parts of Melanesia without any major interruptions for at least the past 2,000 years and probably for much, much longer than this.

What stands out is the evident stability of Aitape's ties with people elsewhere in the southwestern Pacific over such a lengthy period of time. The hypothesis is worth exploring that it has been this local social (and demographic) stability that has nurtured—that is, enabled—the growth of local language diversity on this coast despite the fact that people in the Aitape area have been not only well aware of people elsewhere but also actively dealing with them for untold years.

Chapter 1: Research Issues

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Abstract

We report here on field and laboratory investigations motivated by several complementary issues in anthropology and museum studies that began in 1990 along 350 km of shoreline between the Indonesian border and the small village of Kaiep (or Kep) on the Sepik coast of Papua New Guinea. We also draw on additional information gleaned from the ethnographic material culture collections housed at the Field Museum purchased locally by Museum curators and others a century ago at villages on the 710 km of coast between Madang and the international border with Indonesia.

The Sepik coast of Papua New Guinea (PNG) lies on the leading edge of the Australian tectonic plate, which is in geologically rapid collision with several microplates in the Bismarck Sea (Dam & Wong, 1998; Tregoning et al., 1998). As a consequence, this shoreline is one of the earth's most tectonically unstable areas (McSaveney et al., 2000; Tregoning et al., 2002). Convergence at the North Bismarck plate is ~70 mm/year; lateral shear between them is ~110 mm/year. Major earthquakes occur often. There is ample geological and geomorphological evidence that rapid uplift and subsidence have been common. Volcanic eruptions, large earthquakes, and their associated aftereffects (such as tsunamis and landslides) are potentially catastrophic events that occur here about every 50 ± 25 years (Davies, 2002). Furthermore, the El Niño cycle may bring severe drought followed by high rainfall, flooding, and landslides (Couper-Johnston, 2000), leading to catastrophic landscape change (e.g., Goff & McFadgen, 2002). This coast, which is nearly as straight as a ragged knife edge, is formidable for other reasons, too. The straight-line distance between the coastal town of Finschhaven in PNG and the small island of Pulau Kurudu immediately offshore far to the west in the Indonesian province of West Papua (which together with the Province of Papua has been also called Dutch or Netherlands New Guinea, West Irian, Irian Barat, Irian Jaya, and Papua) is more than 1,300 km: an impressive and near-continental distance by anyone's standard. Except for harbors at Madang and Wewak in PNG and Jayapura (formerly Hollandia) and Sarmi to the west in Indonesia, each of which is today a center of commerce of some local importance, most of this long shoreline is often steep, swampy, or in other ways uninviting, is sparsely inhabited, and has relatively little to offer the commercial markets of the world other than inland forest timber.

These basic facts of geography, geomorphology, and the local environment have direct bearing on the archaeology and prehistory of this lengthy coastline. As will be discussed in this monograph, how people have shaped their lives and crafted their customs in response to its challenges is a remarkable human story, albeit a little-known one. Despite living beside the sea and thus having the appearance of enjoying direct access to the rest of the Pacific, communities today on this coast are economically, socially, and politically remote from the growing urban centers of the modern nation-state of Papua New Guinea—especially Port Moresby, PNG's capital city and economic hub far distant on the opposite southern coast of this immense island. What we have now learned about Sepik prehistory, however, indicates that this coast has nonetheless played a more influential role in the story of the Pacific Islands than generally assumed.

We report here on field investigations under the aegis of the Field Museum of Natural History that began in 1990 in the coastal area comprising the 350 km of shoreline between the Indonesian border in the west and the small coastal village of Kaiep (or Kep) in the east. We also draw on additional information gleaned from the ethnographic material culture collections housed at the Field Museum purchased locally by Museum curators and others a century ago at villages on the 710 km of coast between the international border with Indonesia and Madang (Chapters 2, 8, and 9).

As is obvious from these cartographic distances, our investigations have been extensive in scope. However, the main focus of our work has been centered on the small town of Aitape and nearby offshore islands located in the 200 km of coastline between Serra (Serai) Village west of Aitape and the modern town of Wewak to the east (Fig. 1.1).

Research Issues

The work reported here has been motivated by several complementary issues in anthropology and museum studies. Among these, four have been most influential in shaping our choice of research goals and strategies.

The Myth of the Primitive Isolate

The historian Daniel Smail has remarked that how we see ourselves and the world around us can be haunted by nameless

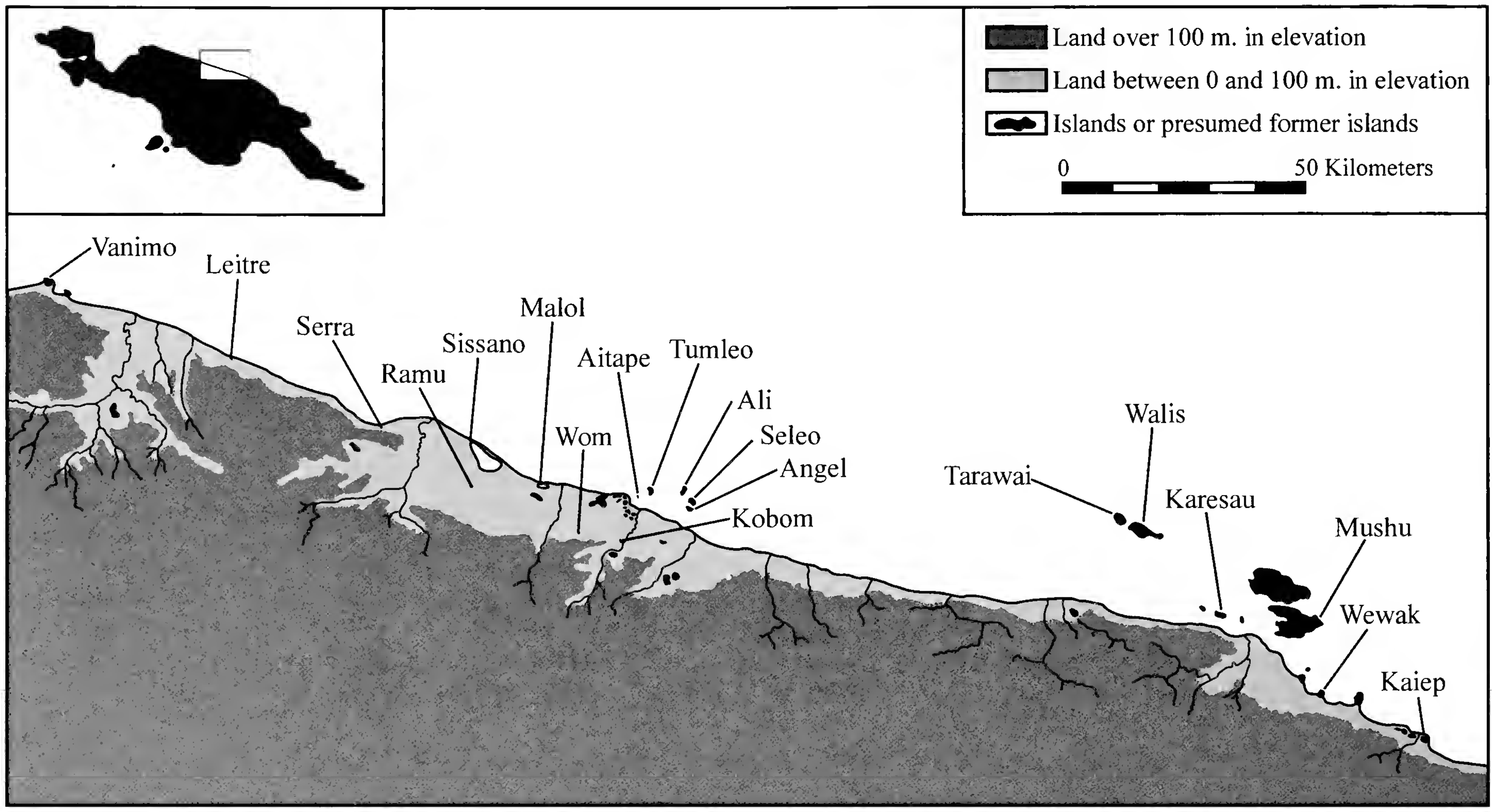

FIG. 1.1. Sepik coast of Papua New Guinea where the investigations reported in this monograph were conducted.

things that he likens to "ghost theories"—by which he means not supernatural premonitions but rather "old ideas that continue to structure our thinking without our being fully aware of their controlling presence" (Smail, 2007, p. 3). One example he offers of such enduring but largely unrecognized attitudes, suppositions, and ideas is the short chronology of the earth's history as framed by the Book of Genesis.

Smail reports that history textbooks used in American classrooms between the late 19th century and the 1940s did not abandon the traditional idea that the earth is only about 6,000 years old—a claim derived from sacred Mosaic history—even though geologists, archaeologists, and other scholars by the mid-19th century had discredited this belief. Instead, American textbooks translated the old Mosaic chronology in a new secular way: "the Garden of Eden became the irrigated fields of Mesopotamia, and the creation of man was reconfigured as the rise of civilization" (Smail, 2007, p. 4).

A similarly enduring ghost theory is the idea that human history before 1492—and if not then, certainly before the development of agriculture and animal husbandry sometime in the early to mid-Holocene (a hypothetical revolutionary event in our history as a species that Smail refers to metaphorically as "the irrigated fields of Mesopotamia")—is a tale about small, wandering, and mostly isolated bands, tribes, or peoples, each out of touch with other similarly small-scale and equally backward human societies elsewhere on earth. This portrayal of our past is one that the anthropologist Alexander Lesser before World War II labeled thought-provokingly as *the myth of the primitive isolate* (Lesser, 1961, p. 42).

Like the biblical creation story, this way of imagining what life was once like for our species was discarded years ago by historians, archaeologists, anthropologists, and others on evidential grounds. Yet this ghost theory survives in popular culture and commercial journalism. This notion still bolsters the commonsense convictions that human prehistory was a time of isolation, fear, and remoteness; that our world even now is a huge jigsaw puzzle of separate and distinct "societies," "cultural traditions," and "ethnic groups" (Lewis, 1991); and that, sadly or thankfully, depending perhaps on your point of view, the traditional diversity of our human ways is now on the wane because e-mail, the Internet, global navigation satellites, and international corporations are presently conquering even the most remote corners of the world. In short, according to this lasting myth, or ghost theory, it was (and possibly still is) their remoteness, hostility, and isolation, not just their technological backwardness, that made "savages" different from you and me.

Rather than being swayed by this traditional view, Alexander Lesser proposed that all of us should instead adopt "the universality of human contact and influence" as our working premise: a way of seeing people long ago or elsewhere on earth not as living in isolation but instead as being caught up "in weblike, netlike connections" with one another both near and far (Lesser, 1961, p. 42). Lesser acknowledged that the social, political, cultural, and economic ties binding people in different places into larger social "aggregates," or fields, have undoubtedly evolved in their intensity and richness over the millennia, but he was insistent that there has never been a time when such connections did not exist or were not in force (Lesser, 1961, p. 47).

As Smail has noted, acceptance of the short Mosaic chronology began to crumble in the 19th century as geologists, archaeologists, and physicists came forward with both evidence and sound arguments that the earth simply must be older than a mere 6,000 or so years. Similarly, what sorts of evidence on this coast can be marshaled to support Lesser's argument that the myth of the primitive isolate is that and little more?

Are Language, Race, and Culture Correlated?

Conventional wisdom tells us that there are different kinds, or types, of people on earth. Once upon a time, even anthropologists thought this was true. The founding fathers of 20th-century American anthropology—notably Franz Boas, Edward Sapir, and Alfred Kroeber—agreed that types of people as conventionally labeled as "Europeans," "Negroes," and "Mongols" genuinely exist. Today, these racial categories have been discarded for good reasons. Even so, many now would probably accept what the remarkably gifted linguist Sapir, for example, wrote in 1921: "Language, race, and culture are not necessarily correlated. This does not mean that they never are. There is some tendency, as a matter of fact, for racial and cultural lines of cleavage to correspond to linguistic ones, though in any given case the latter may not be of the same degree of importance as the others" (Sapir, 1921, p. 230).

In keeping with this elementary but vague logic, language traits are often taken as reliable signs of ethnic identity and origins, and language differences are frequently seen as creating social barriers isolating people from one another. New Guinea is famous for the diversity of the languages spoken on it, popularly said to number somewhere around 1,000. More to the point, linguists tell us that over 60 languages belonging to perhaps 24 different language families are spoken along the 710 km of coast between Jayapura and Madang. The Field Museum's Pacific ethnographic collections include over 6,000 objects collected at many of the villages in this stretch of coastline. It is reasonable to think that this area of New Guinea is a good place to look at how truly "cultural lines of cleavage" correspond to linguistic boundaries using both ethnographic collections and archaeological finds as sources of material witness (Chapter 2).

Is This Coast an "Entangled Bank"?

A third issue motivating our research on the Sepik coast is closely related to the two just described. From a Western cultural perspective, islands are places apart: remote, isolated human enclaves where people are still keeping exotic customs and ideas alive that were long ago abandoned elsewhere by those allegedly less marginal to history and the rise of civilization. From a biogeographical perspective, however, it is probable that once having mastered the technologies and skills required to travel successfully over the open waters of the Pacific, people in Oceania were fully capable of not letting themselves become lost to the world—unless, of course, they had an abiding reason for hiding themselves away or, alternatively, simply did not care about what was happening elsewhere, far or near.

In summary, instead of envisioning the Pacific as a great expanse of open water broken by scattered islands that are "mere specks in comparison with the immensity of the ocean that surrounds them" (Angas, 1866, p. vii), it makes sense to see all the countless inhabited islands of the South Pacific as participants on an immense geographic playing field of island places that have long been in touch with one another—however variably over time and space—and that have followed local but often linked pathways of human adaptation and change.

Said differently, it can be argued from both a human and from a biogeographical perspective that the Pacific has long been an interlocking, expanding, sometimes contracting, and ever-changing geographic set of cultural, social, economic, and political subfields. Therefore, instead of thinking of these islanders as trapped on their islands—in other words, as small scattered primitive isolates—a better way of describing the complexity and interdependence of Pacific peoples is to envision these many landfalls in Oceania collectively, using one of Charles Darwin's metaphors, as an "entangled bank" (Terrell, 1988, 2009).

Many years ago, the Pacific archaeologist Jack Golson (1972a, 1972b, 1982) remarked that New Guinea and the islands in the Bismarck Sea offshore "present a long northern coastline running west to Indonesia, open to receive and transmit cultural influences at all times during the sea-going era" (Golson, 1982, p. 20). Adopted as a research hypothesis, Golson's observation implies that studying prehistory and material culture (including museum collections) on the Sepik coast may be an informative way to explore the ebb and flow of people and ideas across a broad and strategically located swath of the western Pacific. The archaeological and museum investigations described in this report were undertaken to learn how and to what extent this long coastline has been a human "entangled bank."

Making the Most of Museum Collections

As we colloquially like to phrase the issue, can anthropologists do good anthropology with museum ethnographic collections? Or are such collections suitable chiefly for public display in exhibits, creative artistic inspiration, and thoughtful cultural appreciation? What we mean by these seemingly confrontational questions will become apparent shortly, and so this research issue need not be belabored at this point. To be stressed at the outset, however, is that the Field Museum houses some of the largest and most impressive ethnographic collections from the Pacific Islands to be found anywhere in the world. It is appropriate to explore this issue using these remarkable collections.

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Chapter 2: Language, Ethnicity, and Historic Material Culture on the Sepik Coast

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Abstract

The partitioning of people by language is perhaps more extreme on the Sepik coast than anywhere else on earth. Shortly before World War I, the Field Museum of Natural History in Chicago acquired ethnographic material culture collections from a number of village communities there. Computer-aided social network analysis of these collections suggests that isolation by distance, rather than by language, has patterned their cultural relationships. Furthermore, it would be difficult for archaeologists to successfully "reverse engineer" existing language boundaries along this coastline given only observed differences in historic material culture.

Introduction

How many languages are spoken in the world today and how best to read their history depends a lot on what you think languages are and how you go about trying to count them. Even so, by anyone's reckoning, there are an astonishing number of languages in use on the Sepik coast of Papua New Guinea. By some counts, over 60 languages belonging to perhaps 24 different language families are spoken along the 710 km of coastline between Jayapura in Indonesia and Madang in Papua New Guinea. These many languages have been assigned by linguists to five unrelated language phyla: Austronesian and at least four non-Austronesian phyla (Laycock, 1973; Z'graggen, 1975; Wurm & Hattori, 1981; Wurm, 1982; Foley, 1986; Ross, 1988, 1991). What is perhaps even more surprising, however, is that the people living on this coast are not isolated from one another by mountains, rivers, or deeply ingrained traditional hostilities. On the contrary, they are tied to one another by long-standing intergenerational friendships and economic relationships into a vast community of culture, common goals, and shared interests (Welsch & Terrell, 1998).

Research Issues

Three commonsense statements are frequently made about language and language diversity not just in an exotic place like New Guinea but everywhere:

1. *Languages are an ethnic guidebook*—Language is commonly seen as an easy way to define human populations by using language differences to circumscribe, label, locate, and index human beings for data retrieval and comparative research without having to show that the "ethnic groups" or "ethnolinguistic populations" thus recognized are biological or social populations in any meaningful sense of the word, genetic or otherwise. As Luca Cavalli-Sforza and his colleagues once phrased the idea: "except in the case of large modern nations in which the identity of original tribes is usually—though not entirely—lost, languages offer a powerful ethnic guidebook, which is essentially complete, unlike strictly ethnographic information" (Cavalli-Sforza et al., 1994, p. 23).
2. *Language boundaries are material culture boundaries*—It has long been the hope of many archaeologists, in particular, that human social groups have discernible boundaries segregating them from one another that are powerful and durable enough to shape the patterning of material culture. In other words, it has long been conventional to assume that different groups as a rule make and use things in ways that are different enough that archaeologists can succeed at what might be called historical "reverse engineering"—that is, using the spatial and chronological distributions of artifacts and their stylistic characteristics to rediscover long-dead social groups "marked by distinctive patterns in the archaeological record" (Stark, 1998, p. 1).
3. *Language is an "indicator of past history"* (Moore & Romney, 1996, p. 257)—To many people, not just social scientists, it has long seemed self-evident that language differences can be used to pin down not only different societies but also identifiable and enduring ethnic populations (Roberts et al., 1995, p. 775).

However familiar and commonsensical these thoughts may be, they are contestable. More to the point, none of them can be easily tested scientifically, in part because there are few places on earth where languages are varied enough to provide a suitable research setting. In this respect, the Sepik coast of

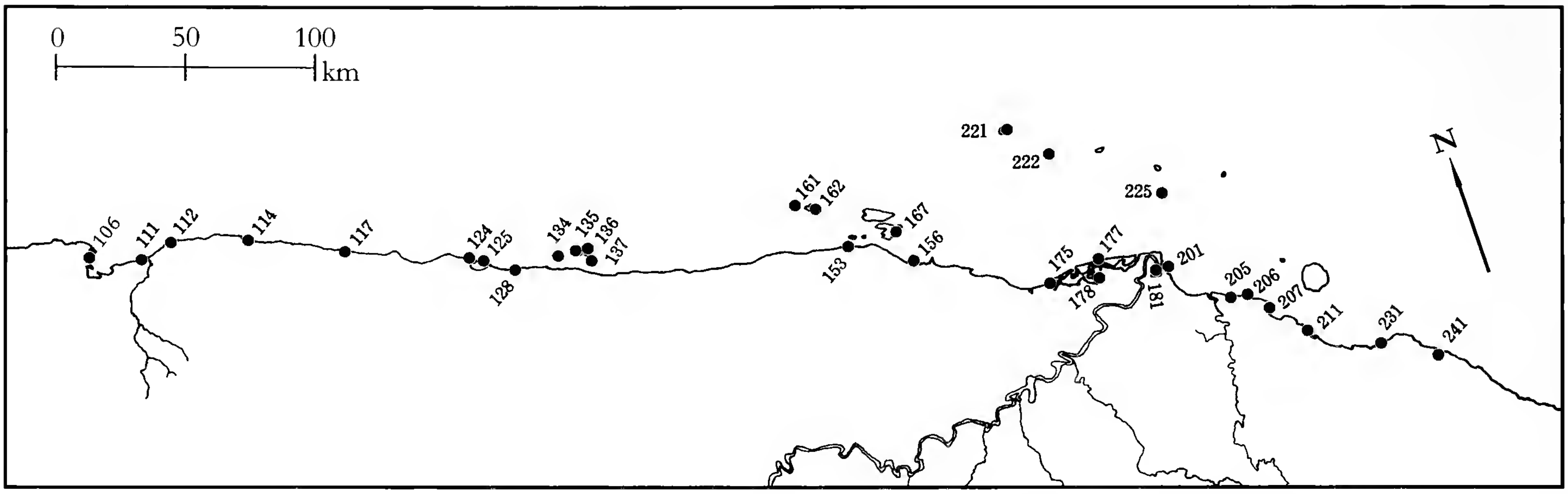

FIG. 2.1. Sepik coast (revised and redrawn from Welsch et al. 1992, fig. 1); names of the numbered locations are given in Table 2.2.

New Guinea qualifies as an unusually appropriate arena for exploring how and how strongly language, culture, human genetics, and history are intertwined. While this monograph is about our archaeological investigations on this coast, it is appropriate to ask in what ways and how successfully the material culture collections from this part of New Guinea curated at the Field Museum of Natural History can also be used to gain better understanding of history and human diversity in this part of the world.

Previous Research

In 1992, Robert Welsch, John Nadolski, and I published a research report in *American Anthropologist* (Welsch et al., 1992) in which we examined the extent to which variation in the kinds of items that had been collected at different villages on this coast (Fig. 2.1) by curators from the Field Museum and others shortly after the turn of the 20th century may be linked with differences in the previous histories of these communities, as suggested by their language relationships, and also with differences in communication, trade, and cultural diffusion among these places, as suggested by how geographically near or far they are from one another. Our report was based largely on our study of over 6,000 objects held in the collections at the Museum purchased before World War I at 31 coastal and offshore island communities located between Humboldt Bay in Papua, Indonesia, and Malala (Kronprinzhafen) in Papua New Guinea (Table 2.1). Our research had been sponsored by a grant from the National Science Foundation (grant BNS-8819618).

In our 1992 report, we explained how we had found that variation in material culture at the turn of the 20th century among these 31 communities had a positive correlation with language and a negative correlation with geographic distance. However, we had also learned that language diversity and geographic distance along this coastline are correlated with one another; that is, they covary. While it could be that both of these two dimensions of life—language and geography—should be taken into account when trying to explain variation in material culture in this part of New Guinea, we finally decided, nonetheless, that variation among the village collections studied can be attributed chiefly to isolation by distance, not to language differences (Welsch et al., 1992).

This conclusion upset some scholars. Reanalyses of our published dataset by others since 1992 have repeatedly concluded to the contrary that "there is no evidence that either distance or language contributes differentially to the explanation of variation among site assemblages" (Moore & Romney, 1994, p. 378). As Moore and Romney wrote in one notably critical essay: "language and distance account for almost identical amounts of variation among material culture assemblages, jointly accounting for 81 percent of observed variation." Or, as they expressed the same thought more simply in the same essay's abstract, "language and propinquity have equally strong effects" (p. 387).

Logicians insist, however, that a correlation is not a cause. Deciding that language is not systematically related to assemblage similarity except insofar as language is associated with geography had not been an easy conclusion to reach (Welsch et al., 1992, p. 585). While it had been simple enough for us to measure the distances between the villages represented in our dataset (we did so as the straight-line distance in kilometers between each and every village) and we had used the object counts in our dataset only in binary format—not the actual numbers of objects—in an effort to deal with our concerns about possible sampling errors, missing data, and the like, we had found no straightforward way to measure language variation among the communities under consideration. Other than those assigned by linguists to the Austronesian language family, each of the local languages and language families has only a small geographic area where it holds sway (discussed below; see Terrell, 2001, pp. 207–208). As we explained in 1992: "This analysis suggests that when language variation correlates with variation in material culture, the association is chiefly a consequence of the geographic clustering of related languages on the coast" (Welsch et al., 1992, p. 585).

Given the hindsight of years, I now wish that we (or someone since 1992) had come up with a more profound way to gauge language variation on this coast than the one we devised (Welsch et al., 1992, fig. 7). The challenge confronting us then can be simply described. While it is not difficult to talk about how *different* from one another these local languages are, it is quite hard to say how *similar* they are in any directly measurable way. Why? When taken all together, these languages are basically *not* similar to one another, at least not similar enough for their similarities and differences to be calculated successfully across the entire range of the differing speech traditions present. The best that can be said about all of them is that they may be assigned linguistically to about seven or so separate language families, each of which has few, if any, discernible ties with the others.

It is my guess that if we had been able to come up with a better way to enumerate language variation on this coast, most—and perhaps all—of the differing objections raised against our conclusions since then, sometimes with remarkable feeling, might have been avoided or at least would not have seemed so pressing in the eyes of those raising them (the various published reanalyses of our dataset are summarized in Shennan & Collard, 2005). Fortunately, however, there are now analytical approaches and software tools that can be used on a dataset like this one that are able to take language variation into account without having to do the impossible—without having to measure language variation directly.

Materials and Methods

For the computer-aided analyses reported here, I have used the same dataset we published in *American Anthropologist* with two modifications. First, in 12 cases we had known in 1992 that an object type had been manufactured in a village at the turn of the 20th century even though the Museum does not have objects of that type from that village in its collections. In our data matrix as originally published, this fact was recorded using a small "b" in the appropriate data cell. In Table 2.1, however, each of these 12 instances has been converted from the letter "b" to the number "1." Second, and more substantially, Potsdamhafen and Kronprinzhafen (211 and 241 in Table 2.1) have been excluded from the analyses reported here because I have not been able to confirm that the provenance associations of the objects listed from these places are reliable (for background discussion, see Welsch, 1996, 1998, 2000).

Since our original study has been both praised (e.g., Barbujani, 1995) and condemned (e.g., Moore & Romney, 1994, 1995, 1996; Roberts et al., 1995) for transforming the object counts given in Table 2.1 into present/absent (1, 0) binary form, I have done the network analyses reported here twice: once using the original full dataset (Table 2.1) and the second time using the same information in transformed binary notation.

Here I have modeled the expected impact of geographic distance on the scope and intensity of interactions among the communities represented in our dataset in two ways. First, I have used the straight-line distances in kilometers among these places as previously reported (Welsch et al., 1992, fig. 2) to generate a spring-embedding network array (Fig. 2.2; for discussion of such networks, see Chapter 7) of expected linkages among the 31 places represented in the dataset based exclusively on their geographic distance from one another. In this instance, all these communities can be joined into a single network at a threshold modeling distance of about 85–90 km or less.

Second, I did a first-, second-, and third-order proximal point analysis (Terrell, 1976, 1986, pp. 130–131) for each community (Table 2.2) to identify probable geographic "neighborhoods" along this coastline (Fig. 2.3). I have used the resulting nine neighborhoods in the analyses reported here to sort out and label geographically each of the village collections in the dataset. As shown in Figure 2.3, these nine neighborhoods can also be grouped into three larger geographic localities—west, central, and east.

It should be noted, too, that at a distance threshold of 52 km or less, all nine neighborhoods coalesce into two major geographic subdivisions: Vanimo, Sissano, and Aitape on the western side of the coastline and all the rest on the eastern side. As discussed here, all analyses of the binary and full datasets show that material culture variation in the dataset mirrors this basic west–east divide.

None of the previously published reanalyses of our Sepik coast dataset by others successfully resolved the difficulties of measuring language variation on this coast. Everybody has done more or less what we ourselves did in 1992, although the statistical approaches adopted by some have not always made this easy to observe. Everyone has accepted that the 31 communities may be assigned to seven or so separate language families (Welsch, 1996). For this reason, Table 2.1 not only gives the object type counts for each of the communities represented in the dataset, but also lists the pooled frequencies for each language family. Since the Austronesian-speaking communities on the coast and offshore islands are so dispersed geographically, the pooled object frequencies for this language family are given under two headings: "western Austronesian" and "eastern Austronesian." The former refers to the Austronesian languages spoken in the Vanimo, Sissano, and Aitape localities, the latter to those spoken in the Schouten Islands.

For the analyses reported here, I used the network software packages Netdraw 2.083, Netminer 3.3.1, and Ucinet 6.207 (Borgatti, 2002; Borgatti et al., 2002; Netminer, 2008) to explore how variation a century ago in the material culture inventories of these Sepik communities may have been associated with language differences among these villagers and with the geographic distances separating them.

Expectations

In their several published statistical critiques of how we handled and interpreted our Sepik coast dataset, as noted previously, Moore and her colleagues were adamant that, contrary to our observations, they had found that "*both* geographic distance and language similarity were *equally* related (within 0.001) to assemblage similarity" and that "both distance and language contribute to the explanation of village assemblage similarity" (Moore & Romney, 1996, p. 235, emphasis in the original). However, from a strictly scientific perspective, having to say that two variables acting together are needed to explain variation in a third might be viewed as an admission of defeat. It is the task of science not to confound variables but instead to isolate them so that their impact can be adequately and effectively assessed. Hence, it is not gratuitous to ask if more can be made of variation in material culture on the Sepik coast than anyone apparently has thus far been able to make of it. In light of previous analyses, the following are expectations for what ought to be observable in this dataset.

Cultural Consistency

All the local languages and language families, with the exception of Austronesian, are strikingly localized in their geographic range. If it is true that (1) languages are an ethnic guidebook, (2) language boundaries are material culture boundaries, and (3) language is an indicator of past history, then the 10 Austronesian communities, which are the most

TABLE 2.1. Distribution of objects in the sample (Welsch et al., 1992: table 2).

Family/ object type	Western AN	Sko	Torri-celli	Ndu	Ndu/AN	Lower Sepik	Ottilien	Kaukom-baran	Eastern AN	106	111	112	114	117
Earthenware	120	4	2	1	1	41	8	0	1	14	2	0	2	0
Wooden dishes	66	39	6	68	8	11	26	7	12	2	0	0	2	0
String bags	63	12	1	25	54	24	17	2	2	3	0	0	11	0
Soft baskets	46	1	0	4	1	11	13	0	1	1	0	0	1	0
Masks	6	3	1	15	30	123	66	0	4	0	0	0	0	0
Carvings	16	24	4	29	48	97	47	0	1	4	10	0	12	0
Bows/arrows	661	670	5	29	29	0	22	16	0	121	55	47	270	171
Spears	12	7	2	0	34	32	89	30	10	2	0	0	7	0
Spear-throwers	0	0	0	0	0	5	5	0	27	0	0	0	0	0
Shields	32	34	0	0	6	5	13	11	0	0	0	3	5	1
Clubs	52	1	0	0	10	3	2	0	40	0	0	0	0	0
Lime containers	112	22	1	0	3	9	4	0	0	47	11	0	11	0
Mortars	0	0	0	0	3	8	12	0	0	0	0	0	0	0
Pestles	34	5	0	3	3	17	5	0	0	0	0	0	0	0
Headrests	57	4	1	5	8	5	21	6	1	15	0	2	1	0
Paddles/canoes	154	62	0	9	5	9	20	10	1	8	8	4	27	0
Hand drums	12	18	0	4	7	7	9	3	3	1	0	0	11	2
Axe/adzes	34	13	1	2	28	18	9	0	5	4	2	3	8	0
Hammers	12	2	3	3	1	8	3	1	3	1	0	2	0	0
Scrapers	46	24	0	11	2	2	1	0	3	1	1	0	23	0
Daggers	36	56	1	8	47	1	1	0	2	3	2	1	50	2
Drills	24	9	0	6	1	12	1	0	0	0	0	0	9	0
Forks etc.	16	30	0	0	0	0	0	0	0	16	1	0	29	0
Spoons	57	0	1	2	3	0	2	0	11	0	0	0	0	0
Nose ornaments	40	14	0	1	1	6	1	0	26	0	0	0	11	2
Hair baskets	1	0	0	4	1	2	8	0	16	0	0	0	0	0
Hair ornaments	41	13	0	0	4	1	8	1	34	2	1	0	12	0
Combs	23	34	0	0	4	1	1	1	15	2	2	4	28	0
Earrings	38	16	0	5	15	0	0	2	2	5	0	0	10	2
Necklaces	15	15	0	3	50	2	2	0	2	1	3	1	7	4
Breast ornaments	35	21	1	3	28	3	4	0	0	1	0	1	15	4
Armbands	40	45	0	24	19	13	4	7	6	4	1	0	35	6
Leg bands	12	11	0	0	11	0	1	0	0	3	0	0	5	6
Forehead bands	30	44	0	3	16	3	5	3	2	1	2	2	28	10
Skirt etc.	1	0	0	1	7	0	10	4	4	0	0	0	0	0
Belts	53	29	0	2	3	5	4	2	7	1	4	0	21	0
Loincloths	8	3	0	2	1	1	6	4	0	0	0	0	3	0
Penis gourds	0	59	0	0	0	0	0	0	0	0	7	14	38	0
Sleeping bags	0	0	0	0	0	7	3	0	0	0	0	0	0	0
Bamboo tubes	24	15	0	0	0	0	0	1	0	5	0	0	15	0
Cups	3	1	0	0	0	10	2	0	0	0	0	0	1	0
Dippers	9	0	0	0	3	0	0	1	0	1	0	0	0	0
Slit gongs	7	0	0	0	0	9	0	4	2	2	0	0	0	0
Breast shields	14	19	0	2	2	0	0	1	0	0	0	2	11	0
Nets	20	0	0	0	1	0	5	0	1	0	0	0	0	0
Baskets	18	0	0	0	0	2	7	1	0	0	0	0	0	0
Rattles	7	0	0	0	6	0	4	0	1	0	0	0	0	0
							7							
5,641	2,107	1,379	30	274	504	513	471	118	245	271	112	86	719	210

broadly distributed of all the local language communities (106, Humboldt Bay, and 225, Kadowar Island, are ~450 km from one another), ought to resemble one another nonetheless in their material culture possessions more significantly than these same communities resemble their more immediate non–Austronesian-speaking neighbors.

Mismatch Linkages

All the communities within each of the language families on this coast—including those within the western and eastern Austronesian divisions as here defined—are within 31 km of one another except for 117 (Leitere in the non-Austronesian Sko family). Most are within 23 km of one another, although in the case of 106 (Humboldt Bay, Austronesian), 125 (Warapu, Sko), 153 (Smain, Torricelli), 211 (Potsdamhafen, which was both Austronesian and Torricelli), and 181 (Kopar, Sepik, paired solely with 201, Watam, Ottilien), the neighboring community at this distance is actually one belonging to a *different* language family. Similarly, at a distance of 31 km or less, four of the 31 communities are still linked geographically *exclusively* with a community or communities belonging to a different language family: 106 (Austronesian) is linked with 111, 112, and 114 (all Sko); 125 (Sko) with 124 and 128 (both Austronesian); 153 (Torricelli) with 161 and 162 (Ndu); and 225 (Austronesian) with 181 (Sepik). Finally, 201 (Watam, Ottilien) is linked with both 181 (Sepik) and 205 (Ottilien). If it is true that the nearer any two communities are to one another geographically, the more likely they are to resemble one another in material culture (even if not necessarily in language), then these spatially "mismatched" communities ought to resemble their "foreign" neighbors with whom they are geographically linked more closely than they do their own language peers. Along with the 10 Austronesian-speaking communities, in other words, these are

TABLE 2.1. *Extended.*

124	125	128	134	135	136	137	153	156	161	162	167	175	177	178	181	201	205	206	207	211	221	222	225	231	241	
10	0	0	93	0	1	2	2	1	0	1	0	6	13	19	3	0	1	0	7	7	1	0	0	0	0	185
17	37	0	11	14	5	17	6	8	51	17	0	2	5	4	0	13	7	5	1	16	9	3	0	0	7	259
2	1	8	7	25	11	7	1	52	20	5	2	1	14	3	6	1	9	1	6	17	0	1	1	1	1	217
16	0	0	7	10	6	6	0	1	4	0	0	1	8	0	2	5	8	0	0	7	1	0	0	0	0	84
0	3	0	0	3	3	0	1	17	13	2	13	51	16	34	22	10	20	28	8	15	2	2	0	0	0	263
0	2	0	0	5	4	3	4	27	12	17	21	32	22	8	35	27	15	4	1	7	1	0	0	0	0	273
43	127	16	258	2	132	89	5	23	29	0	6	0	0	0	0	0	6	9	7	39	0	0	0	1	15	1471
0	0	0	2	2	1	5	2	34	0	0	0	1	0	7	24	2	20	21	46	95	4	6	0	6	24	311
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	2	1	2	22	20	7	0	0	0	59
25	25	4	2	0	1	0	0	5	0	0	1	0	4	0	1	2	5	2	4	3	0	0	0	1	10	104
13	1	1	9	11	8	10	0	10	0	0	0	0	3	0	0	0	0	0	2	0	26	12	2	0	0	108
13	0	7	6	14	23	2	1	1	0	0	2	0	6	3	0	0	2	2	0	5	0	0	0	0	0	156
0	0	0	0	0	0	0	0	1	0	0	2	4	2	1	1	6	5	0	1	0	0	0	0	0	0	23
18	5	2	1	4	7	2	0	3	2	1	0	15	2	0	0	0	5	0	0	1	0	0	0	0	0	68
2	1	7	9	11	10	3	1	7	2	3	1	2	2	0	1	2	9	5	5	17	0	1	0	0	6	125
31	23	17	24	23	39	12	0	1	8	1	4	1	0	2	6	5	6	2	7	5	0	0	1	0	10	275
3	5	0	0	2	6	0	0	4	1	3	3	1	1	0	5	2	6	0	1	8	3	0	0	0	3	71
12	0	1	0	8	5	4	1	28	0	2	0	0	4	2	12	2	5	1	1	2	5	0	0	0	0	112
7	0	0	1	0	3	0	3	1	2	1	0	0	3	1	4	0	3	0	0	0	1	2	0	0	1	36
6	0	9	1	5	12	12	0	2	5	6	0	0	2	0	0	0	1	0	0	3	0	3	0	0	0	92
6	1	0	3	9	6	9	1	42	5	3	5	0	1	0	0	0	1	0	0	0	0	2	0	0	0	152
1	0	0	0	2	13	8	0	0	6	0	1	1	11	0	0	0	1	0	0	2	0	0	0	0	0	55
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46
1	0	0	0	22	14	20	1	3	2	0	0	0	0	0	0	2	0	0	0	8	6	5	0	0	0	84
28	1	1	2	8	1	0	0	1	1	0	0	0	6	0	0	0	1	0	0	25	10	16	0	0	0	114
1	0	0	0	0	0	0	0	1	4	0	0	0	0	0	2	0	4	3	1	10	10	4	2	0	0	42
1	0	1	1	33	1	2	0	4	0	0	0	0	1	0	0	3	5	0	0	11	15	13	6	0	1	113
5	0	0	1	3	2	10	0	4	0	0	0	0	0	0	1	0	1	0	0	5	4	11	0	1	0	84
10	4	1	8	5	5	4	0	15	4	1	0	0	0	0	0	0	0	0	0	4	0	0	2	2	0	82
1	0	0	3	3	1	6	0	48	3	0	2	0	0	0	2	0	0	2	0	6	0	1	1	0	0	95
0	1	6	18	4	0	6	1	28	3	0	0	1	0	0	2	0	2	0	2	5	0	0	0	0	0	100
7	3	2	7	7	4	9	0	17	20	4	2	0	12	0	1	0	2	0	2	12	3	0	3	7	0	170
0	0	3	1	4	0	1	0	11	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	38
7	2	1	1	12	2	6	0	15	2	1	1	0	2	0	1	0	2	0	3	0	1	0	1	3	0	106
0	0	0	0	1	0	0	0	7	0	1	0	0	0	0	0	1	2	5	2	17	0	3	1	2	2	44
9	4	20	8	2	10	3	0	3	0	2	0	0	5	0	0	0	2	0	2	9	0	3	4	2	0	114
2	0	0	0	1	5	0	0	1	0	2	0	0	1	0	0	4	0	0	2	9	0	0	0	4	0	34
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59
0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	1	2	1	0	0	0	0	0	0	0	0	10
3	0	0	1	14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	42
0	0	0	0	2	1	0	0	0	0	0	0	5	2	3	0	1	1	0	0	0	0	0	0	0	0	16
3	0	0	3	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	14
0	0	0	0	0	2	3	0	0	0	0	0	1	0	0	8	0	0	0	0	4	2	0	0	0	4	26
14	6	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	38
3	0	1	0	6	8	2	0	0	0	0	1	0	0	0	0	0	0	0	5	0	1	0	0	0	0	27
7	0	6	0	3	2	0	0	0	0	0	0	0	2	0	0	0	0	0	7	1	0	0	0	0	1	29
1	0	0	1	2	3	0	0	6	0	0	0	0	0	0	0	0	0	0	4	5	1	0	0	0	0	23
328	252	114	489	282	358	265	30	437	201	73	67	125	155	88	145	90	160	92	129	408	126	95	24	32	86	6,049

the places to pay particular attention to in the following analyses (Table 2.3).

Broad Areal Similarity

Before World War I, only one object type (penis gourds) out of the 47 in the dataset was restricted in its distribution to communities solely within a single language family (Tables 2.1 and 2.4; Welsch, 1995). The principal hypothesis we advanced in our 1992 report was not that geography has been more influential than language in structuring material culture variation among the communities represented in the dataset. Rather we argued that the Sepik coast

> is an area within which communities had: (1) a basically similar material-culture tool kit, (2) other shared cultural practices, (3) unifying economic and sociopolitical arrangements, and (4) local specializations in the production of certain handicrafts and other economically important items. Ethnographically, in other words, it can be argued that the [Sepik coast] comprised a remarkably widespread community of culture within which people shared a more or less homogeneous material-culture complex but not a common language. Lack of a common language did not prevent them from interacting with one another and sharing in a common pool of material products and cultural practices. (Welsch et al., 1992, p. 591)

Moore and her colleagues apparently did not find this hypothesis of interest (Terrell, 1995). Even so, they agreed with us that "a core of material culture" (as they labeled the more widely distributed object types) had been shared by many of the communities in our dataset. They maintained, even so, that the less widely distributed types were divided into three discernible

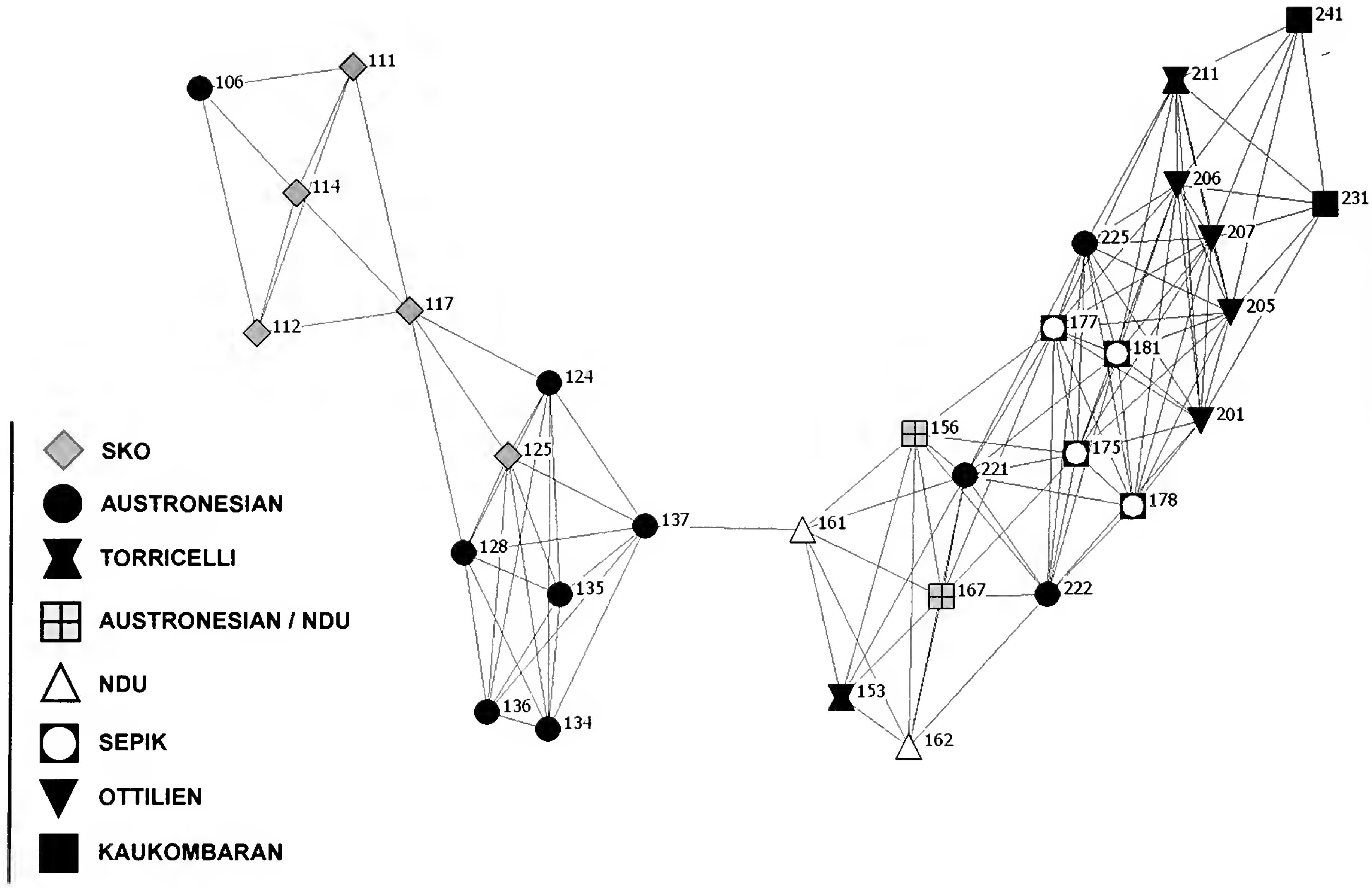

FIG. 2.2. Expected effect of geographic distance on contact among places on the Sepik coast. Spring-embedding network array of the 31 communities represented in the dataset when the threshold distance is 90 km or less, the minimum distance linking all the nodes (places) into a single resulting network. Note how restricted all the language families are with the exception of the Austronesian-speaking communities.

geographic clusters: (1) Sko and western Austronesian, (2) island eastern Austronesian, and (3) eastern non-Austronesian (Moore & Romney, 1994, pp. 383, 386, 387; but see also Welsch et al., 1992, pp. 585–586). If the variation in material culture that exists in this dataset is thus sorted geographically, is it useful to talk about "a remarkably widespread community of culture" in this part of New Guinea?

Results

Figure 2.2 shows graphically how limited is the geographic scope of each of the language families on the coast (as represented by communities in the dataset) except for Austronesian. The positioning of the nodes (communities) in the network illustrated is based solely on the geographic distances between all the communities in the array (Welsch et al., 1992, fig. 2; for a discussion of social network analysis, see Terrell 2010a, 2010b). Figure 2.4 is a spring embedding (also called force directed placement; Fruchterman & Reingold, 1991) network mapping of the Pearson's correlation values among 29 of the 31 communities represented in the dataset based on the object type frequencies given in Table 2.1 when the linkage threshold is a value of $\geq$0.27, the minimum value needed to join all the nodes (places) included into a single network. Given these two mappings, one based on geography and the other on material culture, as well as the supplementary mappings in Figures 2.5–2.11, the following may be noted.

Distance and Object-Type Similarity

The sequential sorting of the language families in the object-type (frequency) space is effectively the same as their relative positions on the coast except in three respects: (1) communities in neighboring language families in Figure 2.4 are more clearly interwoven or commingled than would be expected if Figure 2.2 were used as a mapping of both geography and language; (2) instead of being linked with coastal non–Austronesian-speaking communities in the Wewak, Sepik, and Ramu localities, the Schouten Island (eastern) Austronesian speakers in Figure 2.4 are all linked instead with 231, Hatzfeldhafen, a community in the Malala (Kaukombaran) locality on the extreme eastern side of the study area; and (3) one of the Austronesian-speaking communities on the western side of the study area (135, Ali Island) is unexpectedly and exclusively linked with its eastern counterparts in the Schouten Islands.

The Mantel test of the correlation between matrices is commonly used in population genetics to examine microevolutionary processes, such as isolation by distance (Telles & Diniz-Filho, 2005). This test was used to compare the distance and Pearson's similarity matrices for the 29 communities, resulting in a Mantel $r = -0.476$ with a $p = 0.0005$, a result broadly consistent with previous findings (Welsch et al., 1992; Shennan & Collard, 2005).

Table 2.2. First, second, and third proximal point relationships of the places represented in the dataset (node 211 has been excluded).

Locality	Place	No.	First	Second	Third
Vanimo	Humboldt Bay	106	111	112	114
	Sko district	111	112	106	114
	Wutung	112	111	114	106
	Wanimo	114	112	117	111
	Leitere	117	114	124	125
Sissano	Sissano	124	125	128	134
	Warapu	125	124	128	134
	Malol	128	125	124	134
Aitape	Tumleo	134	135	136	137
	Ali	135	136	137	134
	Seleo	136	135	137	134
	Angel	137	136	135	134
Walis	Tarawai	161	162	153	167
	Walis	162	161	153	167
Wewak	Smain	153	167	162	156
	Mushu Island	167	156	153	162
	Dallmannhafen	156	167	153	162
Sepik Delta	Murik	175	177	178	181
	Kirau	177	178	175	181
	Mabuk	178	177	175	181
	Kopar	181	201	177	225
	Watam	201	181	205	177
Schouten	Wogeo	221	222	167	156
	Koil	222	221	225	175
	Kadowar	225	201	181	177
Ramu	Kayan	205	206	207	201
	Boroi-Bure-Gumi	206	205	207	201
	Hansa Bay	207	206	205	201
Malala	Hatzfeldhafen	231	241	207	206
	Kronprinzhafen	241	231	207	206

Mismatch Linkages

In Figures 2.5–2.7, the eastern Austronesian communities in the Schouten Islands together with Ali Island (135) have been removed from the mappings to highlight more clearly the linkages among the other nodes in the network. Note that the expected mismatch linkages (Table 2.3) are all in evidence as anticipated. However, at a threshold correlation value of ≥0.70 (Fig. 2.6), for instance, three out of the four diagnostic mismatched nodes continue to be linked also with other nearby nodes. The four mismatched nodes identified in Table 2.3 are projected to be linked with six "foreign" nodes, but at the threshold value of ≥0.70, these nodes are still linked with a total of 20 nodes, 13 of which are foreign (Fig. 2.6). In any case, the linkage between 106 and 111 is lost only at a value of ≥0.95, 124 and 125 at ≥0.72, 125 and 128 at ≥0.49, 153 and 161 at ≥0.74, 153 and 162 at ≥0.65, and 181 and 201 at ≥0.71. On the other hand, the projected linkage between 225 (Kadowar Island, Austronesian) and 181 (Kopar, Sepik)

Table 2.3. "Mismatch" linkages between communities belonging to different language families at a distance of 23 km or less; additionally, at a distance of 31 km or less, 225 (Kadowar, Austronesian) is linked with 181 (Kopar, Sepik).

First location, name, and language family	Second location, name, and language family
106, Humboldt Bay, Austronesian	111, Sko district, Sko
125, Warapu, Sko	124, Sissano, and 128, Malol, both Austronesian
153, Smain, Torricelli	161, Tarawai, and 162 Walis, Ndu
181, Kopar, Sepik	201, Watam, Ottilien

seen as probable when the geographic distance threshold is adjusted upward to be ≤31 km is never realized in this dataset (the Pearson's correlation value between these two nodes is −0.14). Instead, 225 is linked first with 135 (Ali Island) at a value of ≥0.43, 222 (Koil Island, eastern Austronesian) at ≥0.37, 221 (Wogeo Island, eastern Austronesian) at ≥0.35, and 231 (Hatzfeldhafen, Ottilien) at ≥0.27.

Broad Areal Similarity

Figures 2.5 and 2.6 also show that geographic variation in material culture from place to place along this coastline divides, as anticipated from first, second, and third proximal point analysis (Fig. 2.3), into three geographic areas—west, central, and east—although again as projected, communities in the central area are tied more closely with places in the eastern area than with those in the west. Figure 2.7 further shows that the commingling of western communities belonging to different language families is evidently stronger than that among those in the east.

Frequencies versus Binary Information

While our worries about using the object-type frequency information rather than the transformed binary dataset have been dismissed by some (cf. Moore & Romney, 1996; Welsch, 1996), there has been no disagreement that there are obvious differences in how many objects of each type there are in the several collections at the Museum used to form the dataset (Welsch, 1996, table VI). Thus, for example, there are 284 bows/arrows in the A. B. Lewis Collection, 1,183 in the Dorsey/Voogdt Collection, and only four in the Parkinson, Finsch, and other early collections included. There are also obvious differences among these various collections in where the objects themselves were acquired. There are 99 objects from Tumleo Island (134) in the Lewis Collection but 408 from there in the Dorsey/Voogdt Collection; similarly, there

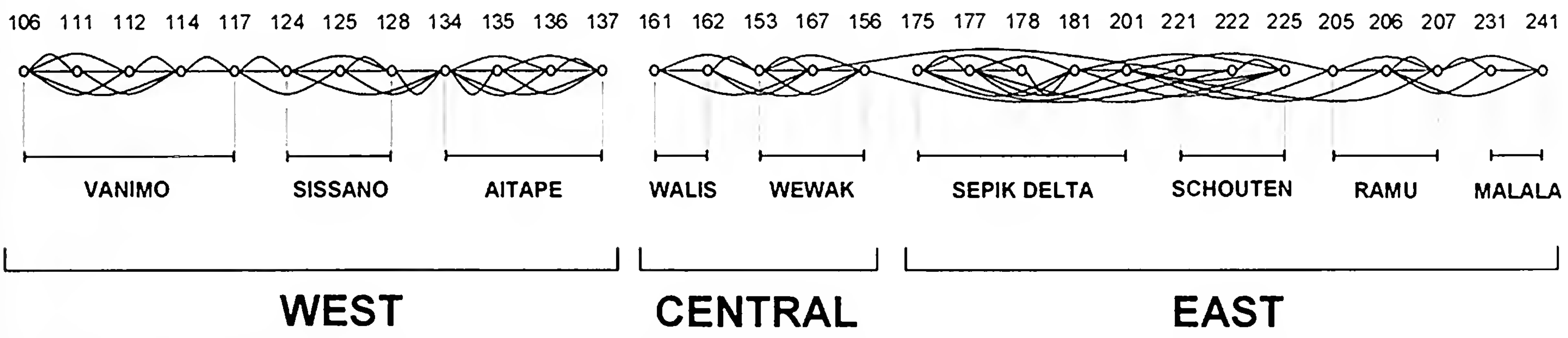

Fig. 2.3. First-, second-, and third-order proximal point mapping of expected geographic neighborhoods (localities) along the Sepik coast in the area represented by the dataset (node 211 has been excluded).

TABLE 2.4. Standardized (percentage) distribution of the 47 object types across the language families in the study area. AN = Austronesian.

Object type	Western AN	Sko	Torricelli	Ndu	Ndu/AN	Sepik	Ottilien	Kaukombaran	Eastern AN
Earthenware	0.67	0.02	0.01	0.01	0.01	0.23	0.04	0.00	0.01
Wooden dishes	0.27	0.16	0.02	0.28	0.03	0.05	0.11	0.03	0.05
String bags	0.32	0.06	0.01	0.13	0.27	0.12	0.09	0.01	0.01
Soft baskets	0.60	0.01	0.00	0.05	0.01	0.14	0.17	0.00	0.01
Masks	0.02	0.01	0.00	0.06	0.12	0.50	0.27	0.00	0.02
Carvings	0.06	0.09	0.02	0.11	0.18	0.36	0.18	0.00	0.00
Bows/arrows	0.46	0.47	0.00	0.02	0.02	0.00	0.02	0.01	0.00
Spears	0.06	0.03	0.01	0.00	0.16	0.15	0.41	0.14	0.05
Spear-throwers	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.73
Shields	0.32	0.34	0.00	0.00	0.06	0.05	0.13	0.11	0.00
Clubs	0.48	0.01	0.00	0.00	0.09	0.03	0.02	0.00	0.37
Lime containers	0.74	0.15	0.01	0.00	0.02	0.06	0.03	0.00	0.00
Mortars	0.00	0.00	0.00	0.00	0.13	0.35	0.52	0.00	0.00
Pestles	0.51	0.07	0.00	0.04	0.04	0.25	0.07	0.00	0.00
Headrests	0.53	0.04	0.01	0.05	0.07	0.05	0.19	0.06	0.01
Paddles/canoes	0.57	0.23	0.00	0.03	0.02	0.03	0.07	0.04	0.00
Hand drums	0.19	0.29	0.00	0.06	0.11	0.11	0.14	0.05	0.05
Axe/adzes	0.31	0.12	0.01	0.02	0.25	0.16	0.08	0.00	0.05
Hammers	0.33	0.06	0.08	0.08	0.03	0.22	0.08	0.03	0.08
Scrapers	0.52	0.27	0.00	0.12	0.02	0.02	0.01	0.00	0.03
Daggers	0.24	0.37	0.01	0.05	0.31	0.01	0.01	0.00	0.01
Drills	0.45	0.17	0.00	0.11	0.02	0.23	0.02	0.00	0.00
Forks etc.	0.35	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spoons	0.75	0.00	0.01	0.03	0.04	0.00	0.03	0.00	0.14
Nose ornaments	0.45	0.16	0.00	0.01	0.01	0.07	0.01	0.00	0.29
Hair baskets	0.03	0.00	0.00	0.13	0.03	0.06	0.25	0.00	0.50
Hair ornaments	0.40	0.13	0.00	0.00	0.04	0.01	0.08	0.01	0.33
Combs	0.29	0.43	0.00	0.00	0.05	0.01	0.01	0.01	0.19
Earrings	0.49	0.21	0.00	0.06	0.19	0.00	0.00	0.03	0.03
Necklaces	0.17	0.17	0.00	0.03	0.56	0.02	0.02	0.00	0.02
Breast ornaments	0.37	0.22	0.01	0.03	0.29	0.03	0.04	0.00	0.00
Armbands	0.25	0.28	0.00	0.15	0.12	0.08	0.03	0.04	0.04
Leg bands	0.34	0.31	0.00	0.00	0.31	0.00	0.03	0.00	0.00
Forehead bands	0.28	0.42	0.00	0.03	0.15	0.03	0.05	0.03	0.02
Skirt etc.	0.04	0.00	0.00	0.04	0.26	0.00	0.37	0.15	0.15
Belts	0.50	0.28	0.00	0.02	0.03	0.05	0.04	0.02	0.07
Loincloths	0.32	0.12	0.00	0.08	0.04	0.04	0.24	0.16	0.00
Penis gourds	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sleeping bags	0.00	0.00	0.00	0.00	0.00	0.70	0.30	0.00	0.00
Bamboo tubes	0.60	0.38	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Cups	0.19	0.06	0.00	0.00	0.00	0.63	0.13	0.00	0.00
Dippers	0.69	0.00	0.00	0.00	0.23	0.00	0.00	0.08	0.00
Slit gongs	0.32	0.00	0.00	0.00	0.00	0.41	0.00	0.18	0.09
Breast shields	0.37	0.50	0.00	0.05	0.05	0.00	0.00	0.03	0.00
Nets	0.74	0.00	0.00	0.00	0.04	0.00	0.19	0.00	0.04
Baskets	0.64	0.00	0.00	0.00	0.00	0.07	0.25	0.04	0.00
Rattles	0.39	0.00	0.00	0.00	0.33	0.00	0.22	0.00	0.06

are 346 objects from Ali Island (135)—Tumleo's next-door neighbor—in the Lewis Collection but only two from there in the Dorsey/Voogdt Collection (Welsch, 1996, table V).

Moore and Romney (1996, p. 238) have questioned whether such obvious differences reflect what Welsch has called "systematic collector bias," that is, whether different collectors preferentially acquired different types of objects on this coast. However, whether collector bias accounts for observed differences among the collections at the Field Museum is tangential to whether it is wise, for example, to think that having only two bows/arrows from Ali Island (135) at the Museum but 258 from Tumleo Island (134), 132 from Seleo Island (136), and 89 from Angel Island (137) (Table 2.1)—all three of which are Ali Island's nearest neighbors—should be seen as a real difference among these communities in their material culture. Considering the object type in question, such an assumption would seem unlikely.

It is known ethnographically that bows and arrows were both widely made and widely gifted from place to place on this coastline (Welsch & Terrell, 1998). We may never know for sure why there are only two bows/arrows in the dataset from Ali Island, but taking this number seriously would seem ill advised. In this regard, recall also that in Figure 2.4, Ali Island (135) is unexpectedly and exclusively linked with the Schouten Islands (221–223), where, according to the dataset, bows and arrows are absent.

On the assumption that bows and arrows were actually more common on Ali Island before World War I than suggested by this dataset, supplementary analyses were done after arbitrarily adjusting the bows/arrows object-type count for this location from 2 to 100, a count roughly intermediate between the frequencies for this object type in the dataset for this island's two nearest neighbors, Seleo (136) and Angel (137) islands (Table 2.1).

As Figures 2.8 and 2.9 illustrate, when this numerical adjustment is made, 135 is now linked with its geographic neighbors. It should be added that there is no substantial shift in the patterning of linkages shown if the numerical value of

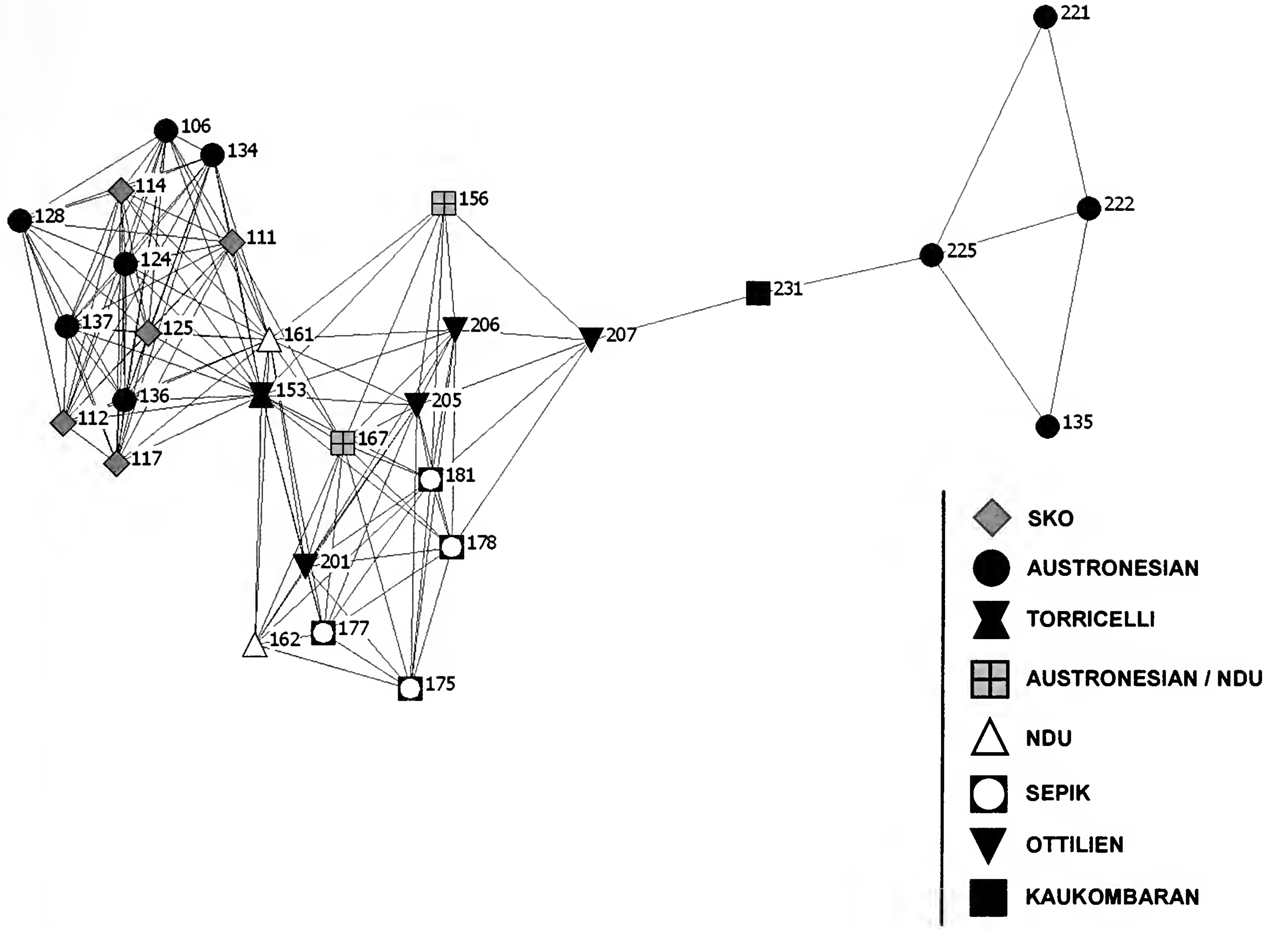

FIG. 2.4. Spring-embedding network mapping of the Pearson's correlation values among 29 of the 31 communities represented in the dataset when the threshold is a value ≥0.27, the minimum needed to link all the nodes (places) in the array.

the adjustment made for bows/arrows for 135 is raised to 200; however, if the number is lowered to 50, node 225 becomes linked at a correlation value of 0.27 or greater not only with 231 but also with 135, confirming that it is the underrepresentation of this object type from Ali Island at the Museum that ties the node representing this island with the Schouten Islands when the unadjusted dataset is used in calculations. Whether this reflects systematic collector bias is an interesting question in itself, but in any case, it is clear that underrepresentation of an object type can affect the integrity of the networks constructed using this dataset.

Transformed Binary Dataset

Figures 2.10 and 2.11 present the results of computing Jaccard and Hamming similarities among 29 of the 31 communities in the dataset using the transformed binary data matrix. While the linkages derived from the Jaccard similarity values (Fig. 2.10) appear to have both local and areal structure (specifically, clustering), the most obvious feature of the resulting Jaccard network is the number and extent of the connections among most of the nodes in the array. Therefore, this network could be used to support the claim that material culture from all across this study area shows it to have been a "community of culture" prior to World War I.

Somewhat in contrast, the linkages derived from the Hamming similarity values form a network that has a more clearly discernible areal structure. Specifically, the separation of the coast into three principal subdivisions (west, central, and east) seems readily apparent (Fig. 2.11). However, there are also obvious anomalies. Two of the eastern Austronesian-speaking communities together with a Kaukombaran-speaking community located even farther eastward are linked in this projected network with both Austronesian- and non–Austronesian-speaking communities in the west.

Object-Type Associations

Some reanalyses of this dataset by others (Moore & Romney, 1994, table 6; Shennan & Collard, 2005, pp. 148–149, fig. 8.3) have suggested that there are meaningful associations among subsets of object types in the dataset. Shennan and Collard (2005, table 8.15) argue, for instance, that 12 object types are particularly associated with the local Austronesian speakers. However, if the distinction between western and eastern Austronesian-speaking communities is made, only three object types (clubs, spoons, and hair ornaments) retain such an

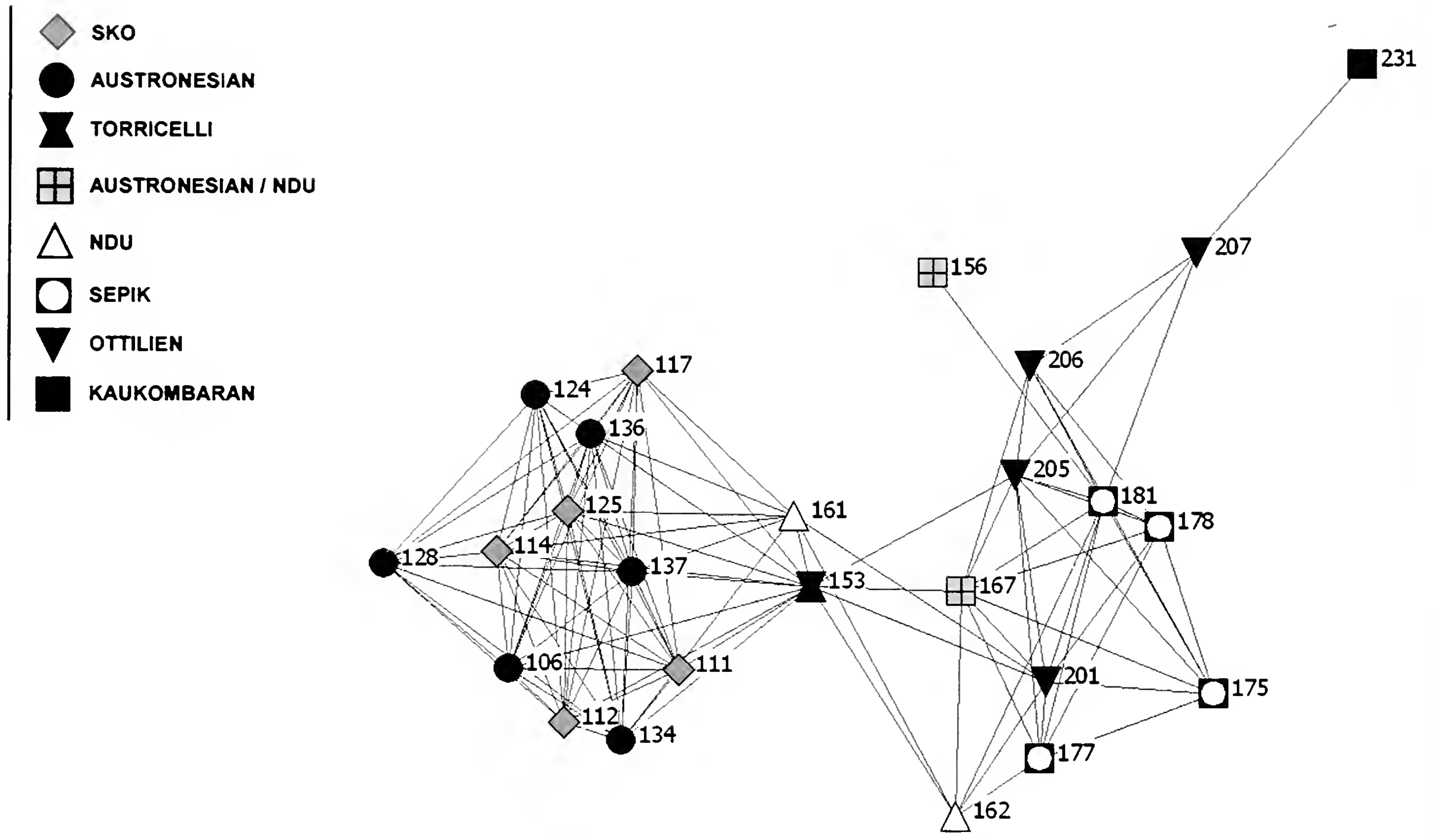

FIG. 2.5. Network mapping of the correlation values among the 25 of the 31 communities represented in the dataset when the threshold is a value ≥0.39, the minimum value needed to link all the nodes (places) in the array (nodes 135, 211, 241, 221, 222, and 225 have been excluded).

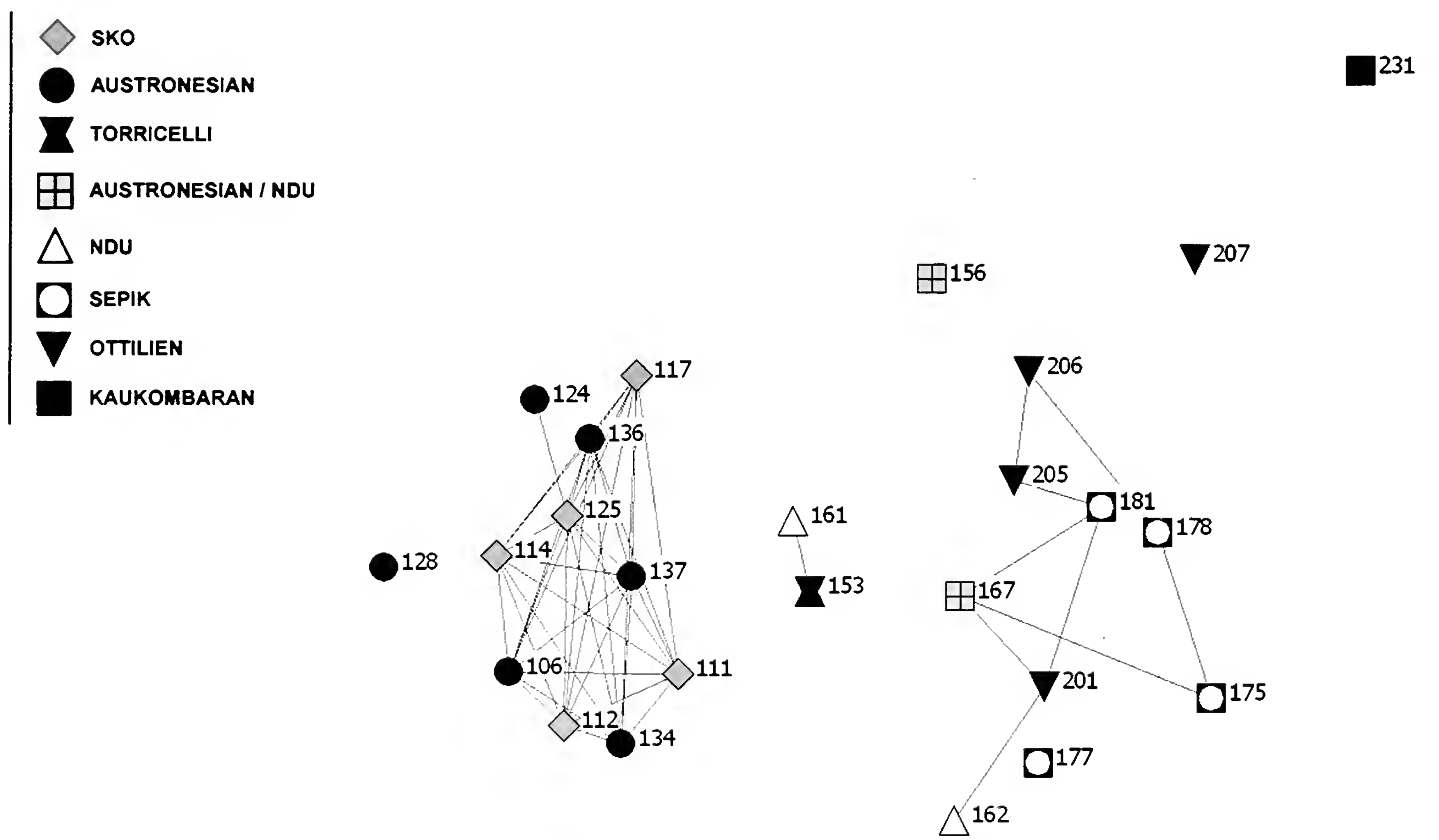

FIG. 2.6. Network mapping of the correlation values among the 25 of the 31 communities represented in the dataset when the threshold is a value ≥0.70 (nodes 135, 211, 241, 221, 222, and 225 have been excluded).

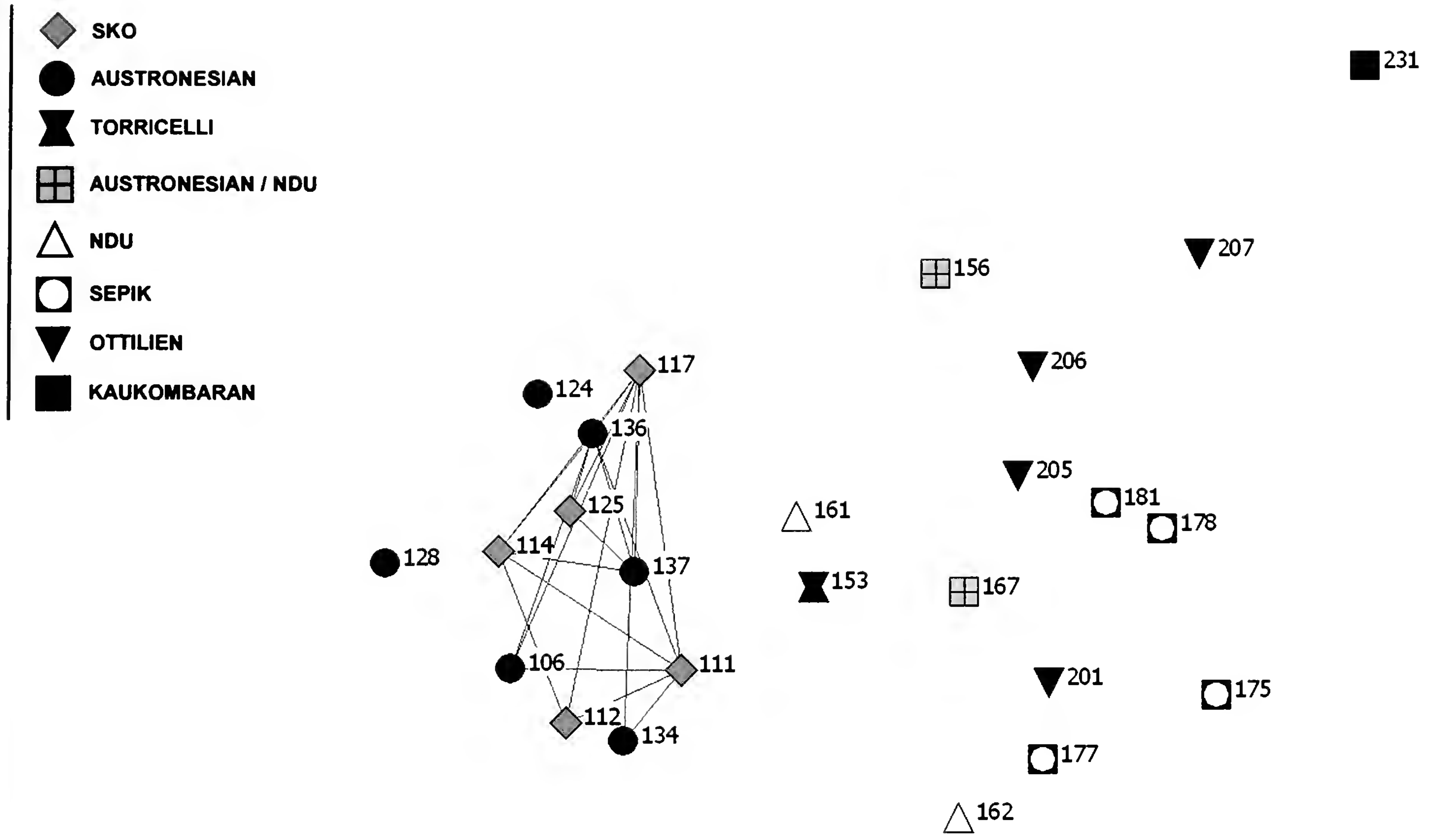

FIG. 2.7. Network mapping of the correlation values among the 25 of the 31 communities represented in the dataset when the threshold is a value ≥0.90 (nodes 135, 211, 241, 221, 222, and 225 have been excluded).

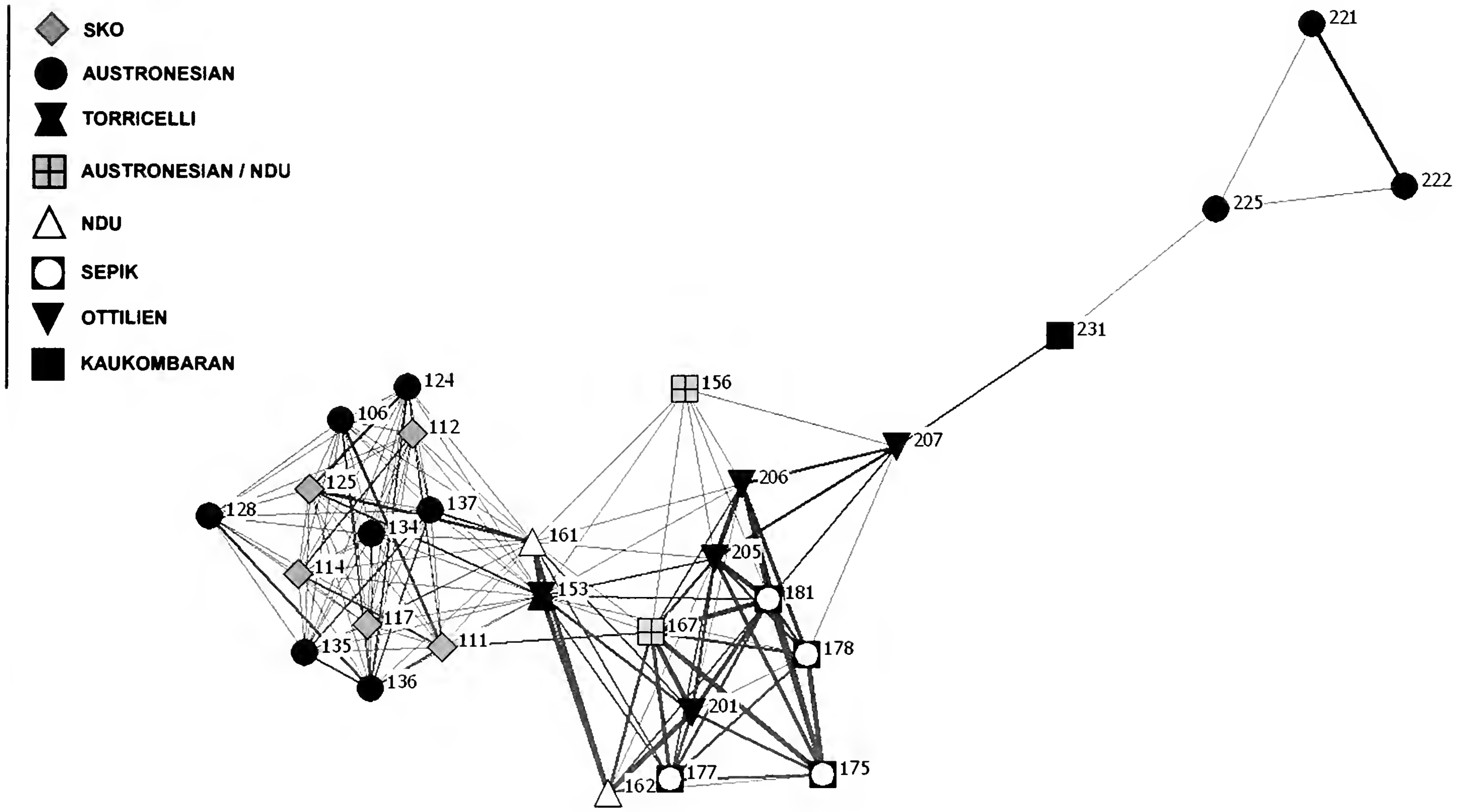

FIG. 2.8. Spring-embedding network mapping of the Pearson's correlation values among the 29 of the 31 communities represented in the dataset when the threshold is a value ≥0.27, the minimum needed to link all the nodes (places) included in the array, and the number of objects of the type "bows/arrows" in the dataset for Ali Island (135) is adjusted from 2 to 100.

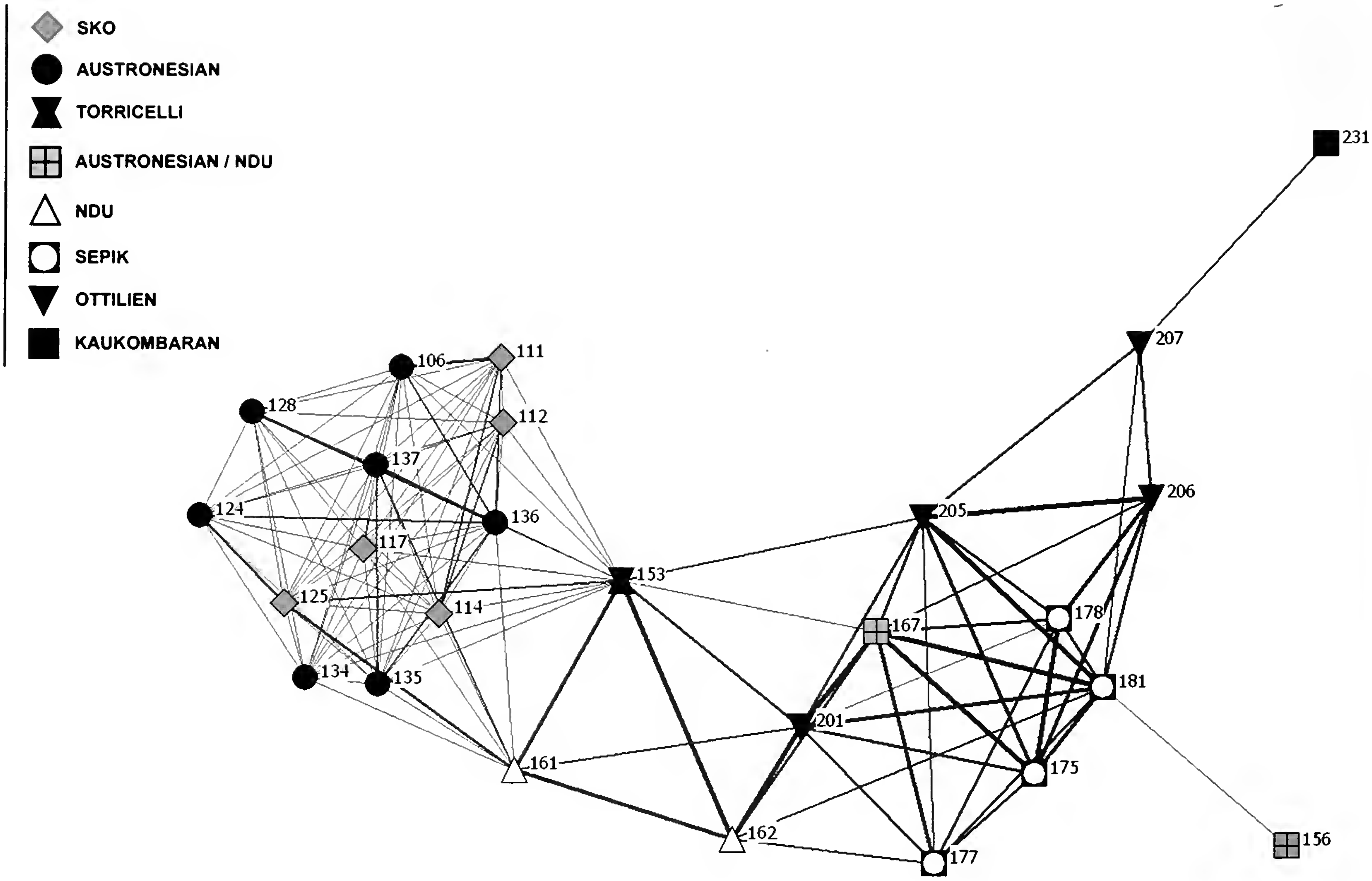

FIG. 2.9. Spring-embedding network mapping of the Pearson's correlation values among the 29 of the 31 communities represented in the dataset when the threshold is a value ≥0.39, the minimum needed to link all the nodes (places) in the array, and the number of objects of the type "bows/arrows" in the dataset for Ali Island (135) is adjusted from 2 to 100 (nodes 211, 241, 221, 222, and 225 have been excluded).

apparent association. Yet, as Welsch has explained with regard to an entirely different triadic subset of items (penis gourds, forks, and sleeping bags) in the 47-object-type dataset:

> Only three of these types genuinely seem to have distributions that are associated with only one or two language families. There is absolutely no reason to believe that these three object types are ancient traits that have been preserved as distinctive features of their language families. Instead, penis gourds, forks, and sleeping bags would seem to be relatively late additions to or adaptations of more basic tool kits. Such associations do not suggest that material culture is a good predictor of language affiliation—except in these three cases. (Welsch, 1996, p. 212)

While insightful, this statement must be qualified. In the case of forks and sleeping bags, their distributions are more certainly geographic than linguistic; that is, each of these two object types is shared by communities belonging to two different but neighboring language families—two language families in the west (forks) and an entirely different set of two in the east (sleeping bags).

Discussion

The evidence considered here has only been circumstantial. Illusionists know that much can be built on the premise that "seeing is believing." It is not obvious how much should be made of what has been reported here.

No one, however, has doubted our claim in 1992 that isolation by distance had played a role in structuring variation in the material possessions of people in different communities on the Sepik coast. It has been said instead that we have "overdrawn the case against language" and have promoted "an unduly pessimistic view" (Moore & Romney, 1994, pp. 387, 388).

If there is any place on earth where language differences ought to be structuring material culture variation among different communities, the Sepik coast should be the place. The partitioning of the coast by language is perhaps more extreme than anywhere else in the world. People in neighboring communities may speak not only mutually unintelligible languages but also languages that are so markedly different from one another that they are assigned by linguists to entirely separate language families. Hence, if it is true that language boundaries are also material culture boundaries, then it ought to be possible to see correlations between language and culture on this coast that are unambiguous and unmistakable. Yet once again, it has been possible to show that this is evidently not the case. The role of geographic distance in patterning material culture variation is apparent; the role of language is not.

Some may still find this conclusion unacceptable. Therefore, it seems pertinent to add that one way to grasp the weakness of the argument that language has played a significant role in patterning the cultural variation under consideration is to ask two rhetorical questions. First, given only the Museum's ethnographic collections to examine, how reliably would

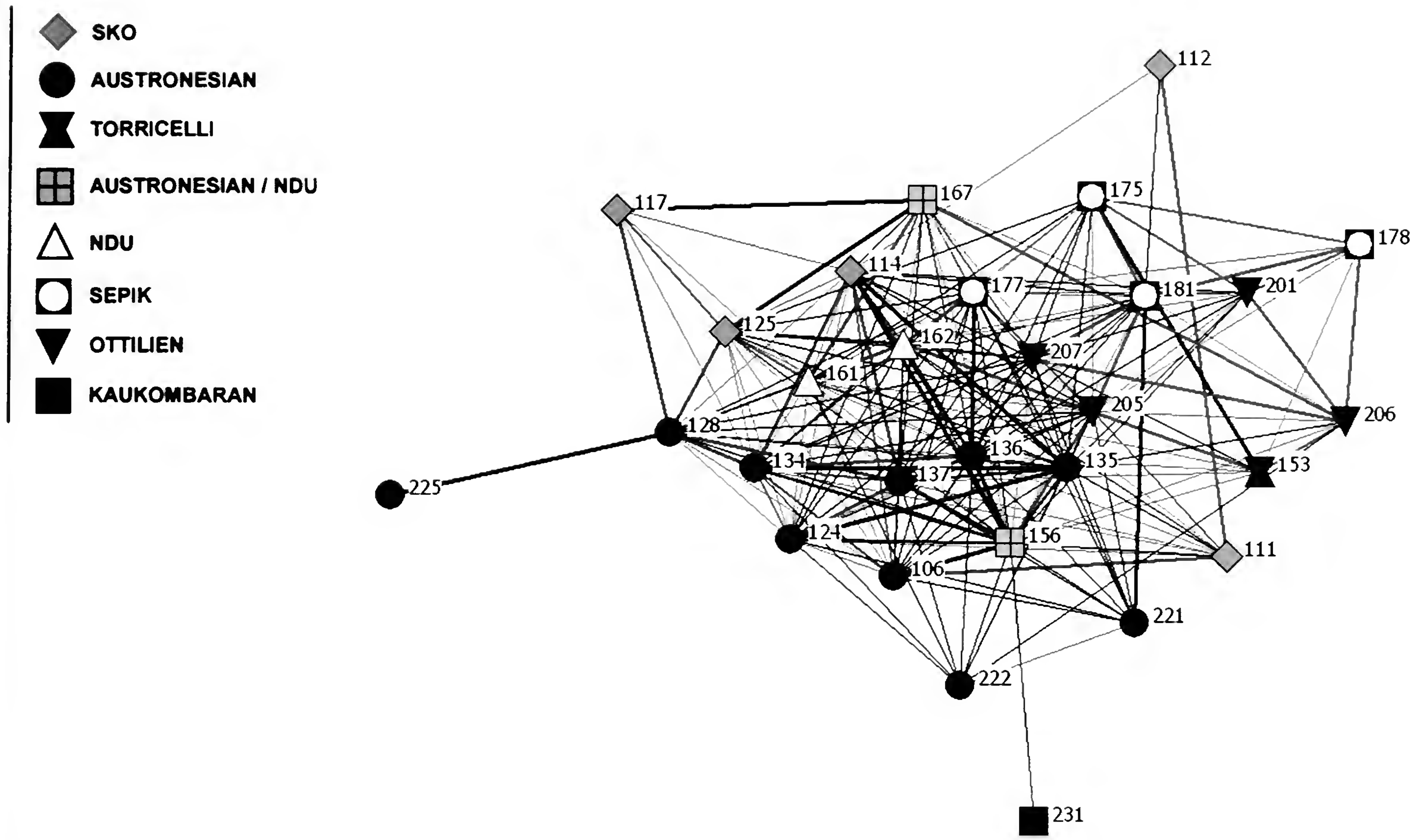

FIG. 2.10. Spring-embedding network mapping of the Jaccard similarity values among 29 of the 31 communities represented in the dataset when the threshold is a value ≥0.34, the minimum needed to link all the nodes (places) in the array.

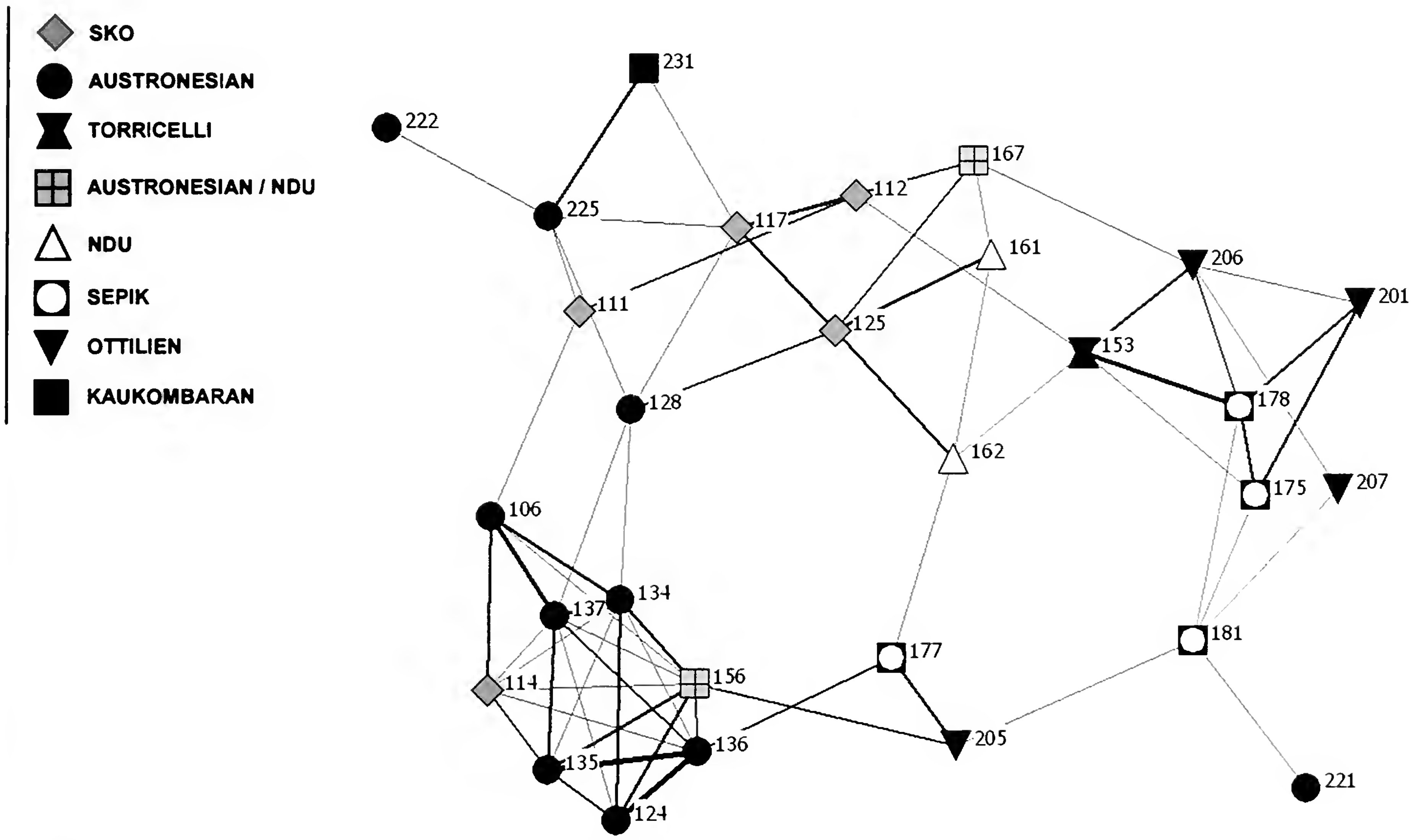

FIG. 2.11. Spring-embedding network mapping of the Hamming similarity values among 29 of the 31 communities represented in the dataset when the threshold is a value ≥32, the minimum needed to link all the nodes (places) in the array.

archaeologists be able to "reverse engineer" language boundaries along this coastline? Second, what would archaeologists be able to say about any of the "ethnolinguistic populations" they reconstructed using this evidence?

It is likely that archaeologists would be able to reconstruct statistically significant *geographic* differences among communities located on this coastline—east, west, central, and perhaps the eastern islands, too—but they would be in error in at least three out of these four cases if they then went on to infer that these reconstructed geographic subdivisions had once upon a time been inhabited by four ancient "ethnolinguistic populations" having boundaries that were coterminous with ones suggested by the material cultural evidence they had surveyed.

Why have others insisted, nevertheless, that language differences have played an equal role with geographic distance in structuring variability in material culture along this coastline? The reason is not difficult to discover. The reanalyses done by others have relied on a logical premise that may sound perfectly reasonable but that is a poor choice at least in this part of the world. Evidently, without realizing the significance of what they were putting into words, Moore and Romney succinctly phrased this misleading assumption in 1996: "if language is not related to similarity, then villages in each language family would be distributed at random, not clustered in the same area" (Moore & Romney, 1996, p. 255; see also Shennan & Collard, 2005, p. 148).

Here, the "area" they are referring to is not the actual Sepik coast viewed as a geographical area but rather their several two-dimensional chartings of the similarities and differences they had computed among the communities represented in the dataset using several differing statistical ways of looking for patterning among the values in a data matrix. In the following statement, nonetheless, the word "area" can be read either way without distorting the lesson to be drawn:

> The logic of using these figures to make a visual inspection of whether or not language (or any other variable) is related to artifact assemblage similarity is clear. The location of the villages [in the diagrams] reflects artifact assemblage similarity. We determine whether or not villages in a given language group are similar to each other by examining whether or not villages speaking a given language "cluster," i.e., are close to each other in the figure. If language is not related to similarity, then villages in each language family would be distributed at random, not clustered in the same area. When villages of a given language group all cluster close together [in these figures] then that means they are similar in terms of artifact assemblage similarity. . . . Thus, even if one rejects our scaling of linguistic similarity … the treatment of language as a categorical variable clearly shows strong relationship to village similarity. (Moore & Romney, 1996, pp. 253, 255)

The analyses reported here have shown once more that given the information in Table 2.1, language is related to object-type similarity among these communities because—as we originally observed back in 1992—object-type similarity in the dataset is related to the geographic clustering of the communities in the study area. Whether language has anything to do with the variation under consideration is moot. This is not what common sense would lead us to expect. Therefore, this observation has been a lesson worth repeating here.

Conclusions

While it has been possible to use the ethnographic collections at the Field Museum to demonstrate that isolation by distance had evidently led to geographic patterning of variation in material culture among communities on the Sepik coast prior World War I, the analyses reported here offer little support for the suggestion that there was also then "a strong relation between language and material culture" (Moore & Romney, 1994, p. 389) of equal explanatory relevance and interest. As the old saying goes, appearances can be deceiving.

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Chapter 3: Context and Relevance

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Abstract

Given what is now known or may be reasonably inferred about the geomorphological development of the northern shoreline of New Guinea—the second-largest island in the world with a land area of about 808,000 km^2—this island has played a previously unexpected role in the prehistory of the Pacific, first as "barrier" and then later as "bridge" (or perhaps, more accurately, as "voyaging corridor") between island Southeast Asia and Oceania. However, our field investigations since 1990 have shown us that people living on this tectonically unstable coastline have developed specific ways to handle the challenges of living in such a hazardous and changing environment. One of these strategies is the locally well-established institution of inherited friendship (more commonly referred to in the anthropological literature as "trade partnership"). The second, as yet still insufficiently documented on this coast, is the transgenerational management of resources.

Introduction

Human range expansion has long been accepted as a key dimension of prehistory in the Pacific Islands (Pope & Terrell, 2008). It has been only in the past few decades, however, that the real antiquity of human settlement in the western Pacific has been recognized—conservative estimates suggest that we are looking at ~40,000–45,000 years of human history in Australia and the southwestern Pacific. It has become increasingly evident that there has been more than enough time since the first arrival of people for local biological and cultural evolution to be much more than a minor motif of this region's prehistory.

Earlier investigations in the Sepik-Ramu River basin by Pamela Swadling and her colleagues as well as our own on the Sepik coast have together led to a number of observations and inferences about the evolution and chronology of northern New Guinea as a landscape open to human settlement and use (Swadling, 1997; Terrell, 2002, 2004a, 2004b, 2006). It may now be inferred from what has been learned that this island—the second largest in the world with a land area of about 808,000 km^2—has played a previously unexpected role in the prehistory of the Pacific.

Earlier Suppositions

Once upon a time it seemed self-evident to many foreigners that Pacific Islanders could be divided up into a small number of distinct and separate "nations," "racial groups," or (today) "phylogenetic lineages." Furthermore, it was long held that these supposedly different peoples, populations, or races each must have had its own (more or less) unique history of migration and settlement in Oceania (Douglas & Ballard, 2008). Even today, many would say that however much these different groups or populations may have become intermixed over time following their arrival in the Pacific, it should still be possible for scientists to unravel the historical lineages of these separate component peoples given due diligence and the proper computer programs (e.g., Hurles et al., 2003).

In its most generic form, this long-established conventional wisdom posits the former existence in the Pacific of two ancient peoples or races, one of which used to be called "Polynesians" and the other "Melanesians." Today, these two supposedly different peoples are more often talked about (using labels taken from linguistics) as the "Austronesians" and the "Papuans," respectively (Terrell et al., 2001). At its root, this simple binary classification of Pacific Islanders is more or less as old as foreign adventurism in this part of the world (e.g., Prichard, 1813).

It has also long been conventional to say that Melanesians/Papuans were the first people to reach New Guinea and other neighboring islands in the southwest Pacific; Polynesians/Austronesians arrived much later during a time of extraordinary human migrations out of southern China or Taiwan, fueled or facilitated in some manner by something entirely new

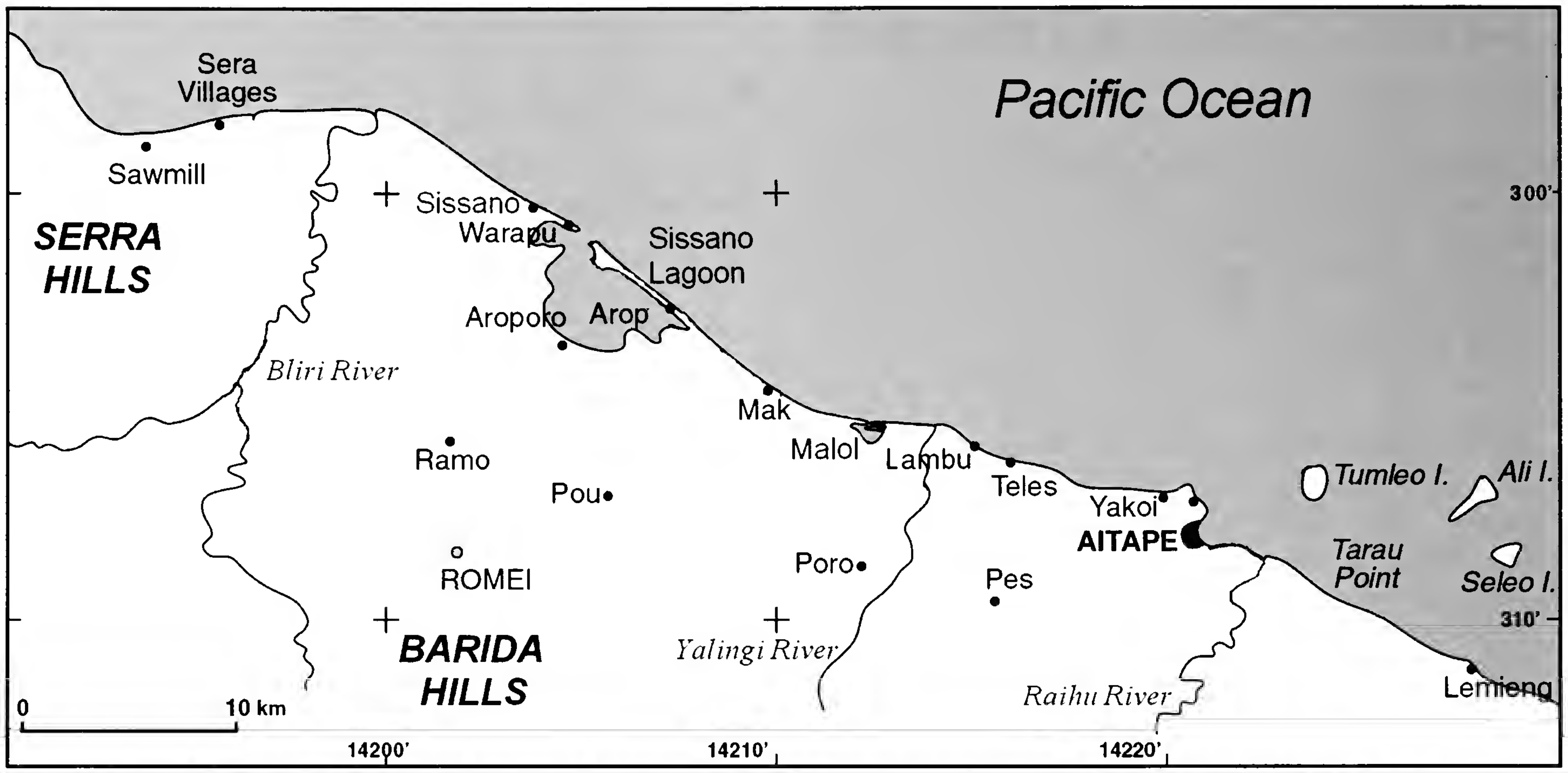

FIG. 3.1. The Aitape region of the West Sepik coast, Papua New Guinea (base map adapted from Davies et al., 2003).

and remarkable in human history: the development of agriculture and food production during something called the "Neolithic Revolution" (Bellwood, 2002, 2005; Diamond & Bellwood, 2003).

Thus, according to this long-held interpretation, Pacific prehistory is a story about two "populations with quite different backgrounds" (Thomas, 1997, pp. 133–134) who entered Oceania in two different waves of migration at two separate times in the past. Furthermore, there was supposedly also something decidedly better and extraordinary about the second great migration. The migrating Melanesians were only hunters and gatherers of what they ate. The itinerant Polynesians were that and more, much more. They were food makers, not just food consumers.

This monograph is about archaeological investigations on the Sepik coast. Its scope is too confined to challenge directly this old conviction that the story of the Pacific is a story about two peoples and two migrations. What we now know about Sepik prehistory, however, offers little support for this way of thinking and writing about the prehistoric Pacific Islanders.

Geomorphology

What is now known or may be reasonably inferred about the geomorphological development of the northern shoreline of New Guinea since the end of the Pleistocene suggests that the story about two peoples and two periods of migration not only is too simple a reconstruction of the past but also may be misleading.

FIRST WORKING HYPOTHESIS—*During the late Pleistocene and early Holocene, there were few stable, productive lowland areas along the northern coastline of New Guinea suitable for human use; as a consequence, this coastline was only sparsely inhabited by people before ~6,000–7,000 years ago.*

For something like 227,000 of the past 250,000 years, the world's sea levels were 10 m or more below their present stand (Voris, 2000, p. 1164; Sathiamurthy & Voris, 2006). Archaeologists today largely agree that *Homo sapiens sapiens* reached New Guinea at least 35,000 years ago during the late Pleistocene (e.g., Groube et al., 1986; O'Connell & Allen, 1998; Chappell, 2005). Dates for early human settlement in Australia suggest initial occupation of New Guinea may have been earlier than this, perhaps well before 40,000 years ago (Turney et al., 2001; Bird et al., 2002; Bowler et al., 2003) or even ~60,000 years ago (Roberts et al., 1994).

For much of the last glacial epoch (i.e., ~50,000–28,000 BP), global sea level fluctuated between 70 and 90 m below present mean sea level (pmsl), dropping to ~130 m below pmsl at the last glacial maximum ~18,000 BP, before rising rapidly to near modern levels ~7,000 BP (e.g., Chappell & Shackleton, 1986; Chappell & Polach, 1991; Chappell et al., 1996; Chappell, 2005). Until then, southern New Guinea was attached to Australia by a land bridge across the Torres Straits (Voris, 2000, p. 1164; cf. Lambeck & Chappell, 2001).

A reconstruction of glacial maximum coastal environments along the Sepik coast in the vicinity of Aitape is shown in Figure 3.2 based primarily on a lowering of sea level. The coastline is drawn at the 100-m isobath (assuming there is about 20–30 m of postglacial sediment on the shelf; Tappin et al., 2001). The continental slope between depths of 100 m and 70 m is quite steep (Fig. 3.2; Imamura & Hashi, 2003) such that the coastline at ~40,000 BP would be only ~2 km inland from the one shown in Figure 3.2. This map provides a rough approximation of what the Sepik shoreline was like for the last 40,000 years of the Pleistocene.

The late Pleistocene drop in sea level led coastal rivers to incise their channels, coastal swamps to dry out, lagoons to disappear, and reefs to contract (Chappell, 1982, 1993b). The relatively straight, braided river channels found in the Aitape area today would have extended down to near the coast, the extensive swamp land would have contracted to the zone of

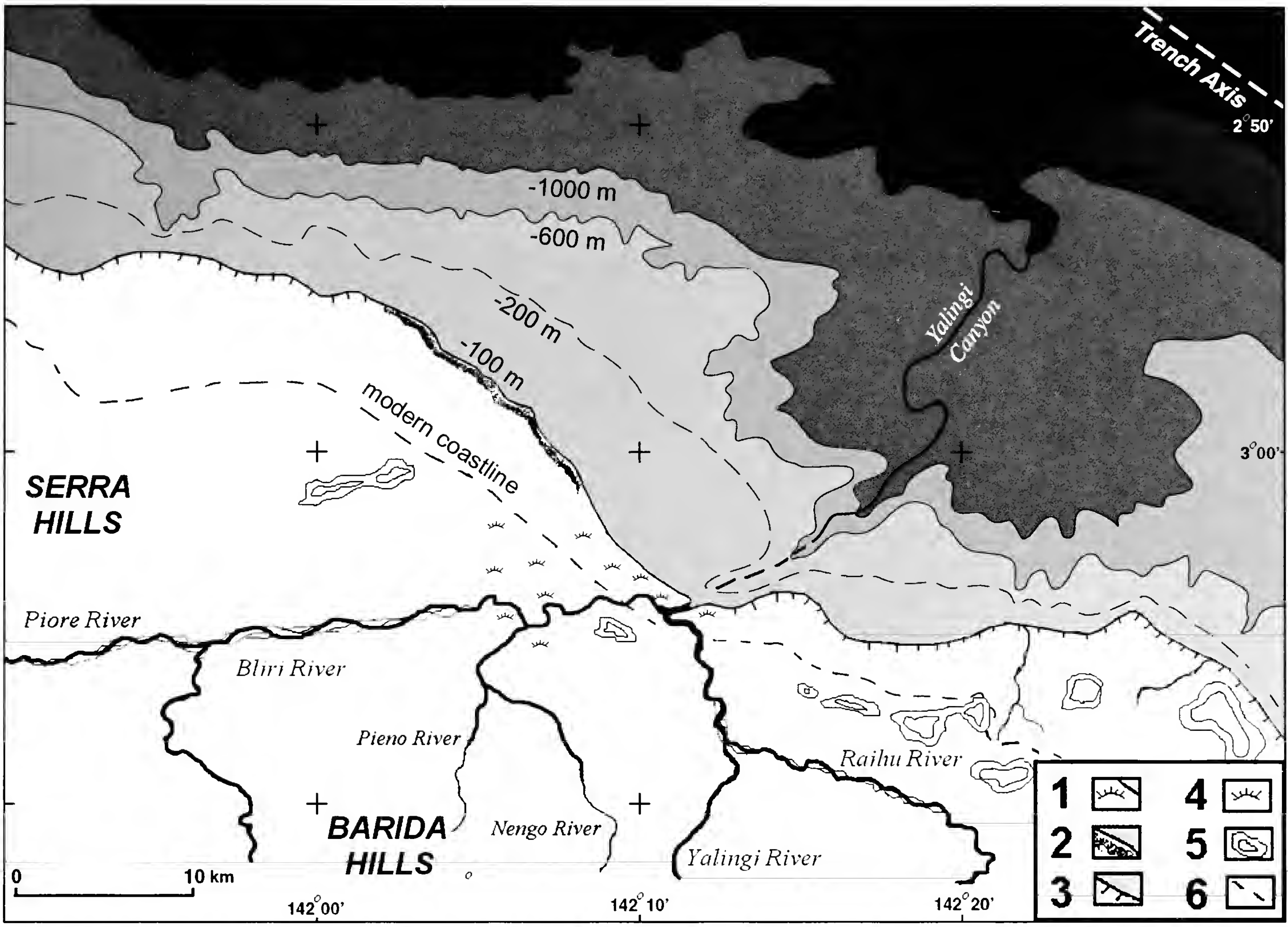

FIG. 3.2. Hypothetical reconstruction of the Aitape region of the West Sepik coast, Papua New Guinea, ~18,000 BP. Key: (1) swampy, muddy coast with mangroves; (2) sandy coast; (3) rocky coast with emergent coral reefs; (4) fresh- and brackish water swamps; (5) coastal plain hills; (6) trace of modern coastline. Map base adapted from Davies et al. (2003).

major subsidence (near the current location of Sissano Lagoon), much of the coastline would have been dominated by rocky shores composed of emergent coral reefs, and lagoons would have been rare or absent (Fig. 3.2).

Because of the steep coastal gradient and the rapid postglacial sea level rise (over 1 cm/year until around 8,000 years ago; see Chappell, 1974; Fairbanks, 1989; Chappell & Polach, 1991; Lambeck & Chappell, 2001), it is probable that this rocky coastline persisted until about 6,000–8,000 years ago, when the change in sea level slowed and coastal sedimentary environments had a chance to develop (Chappell, 2005). Even now in the Aitape district, for instance, the narrow but rugged Torricelli Mountains (which rise to an elevation of 1600 m roughly 30 km inland from the coast) form a challenging barrier between the narrow coastal strip of forested lowland alluvial plains and swamps, which is at most 10–15 km wide, and the interior of the island (Figs. 3.2 and 3.3). Furthermore, there is little in the way of a marine shelf off this shoreline to offer fertile shallows readily exploitable for human subsistence.

Hence, it is probable that there were few stable, productive lowland habitats along this coast suitable for use by anyone during the late Pleistocene to early Holocene. It is likely that Pacific Islanders were only sparsely inhabiting this coastline before mid-Holocene times.

> SECOND WORKING HYPOTHESIS—*Since the middle Holocene (after ~7,000 BP), local geomorphic conditions have led to the development of the biologically complex lagoon–swamp–forest ecosystems that are at present—and probably were in the past as well—the habitat on this coastline most favored for settlement.*

It can be argued that stabilization of the world's coastlines after the Pleistocene, combined with modern climatic conditions, created widespread coastal habitats favorable to human subsistence and settlement on a scale that had not been matched since the previous interglacial climax ~120,000 years ago (Bailey & Parkington, 1988). The lower reaches of the short river systems that exist today along the northern coastline of New Guinea carry significant amounts of sediment to the sea from the nearby mountains; they have wide braided beds because of the sudden sharp decrease in gradient when they emerge from the mountains (McSaveney et al., 2000). Once sea level rise had decreased to <1 cm/year around 8,000 years ago (Fairbanks, 1989; Dickinson, 2001), it is likely that relatively stable bay, lagoon, and estuarine ecosystems began to form along this coast as waterborne sediments started to accrete where favorable configurations of shoreline, local subsidence, and offshore islands trapped sediment in sandbars, lagoons, and small river deltas.

Holocene paleoenvironmental data for the West Sepik (Sandaun) region are sparse, but information is available for the lower Sepik-Ramu region approximately 230 km east of Aitape. Data from shallow coring, river cuts, and archaeological excavations indicate that the postglacial rise in sea level flooded the entire lower Sepik-Ramu basin with brackish water to form a large shallow inland sea that reached its fullest extent 6,500–7,500 years ago (Swadling et al., 1989, 1991, 2008; Swadling & Hope, 1992; Chappell, 1993a; Swadling & Hide, 2005). Research at the Dongan shell midden 17 km from the coast records extensive human exploitation of shallow marine and estuarine resources ~5,800 BP, followed by a sea-level rise and submergence and abandonment of the site (Swadling et al., 1989, 1991; Swadling & Hope, 1992). Other middens in the area produced radiocarbon dates of ~5,700–5,400 BP as well as late Holocene dates for sites closer to the coast.

Sea-level data from the tropical Pacific indicate that sea level rose rapidly in the early Holocene, reaching or exceeding present levels ~7,000 BP (e.g., Chappell & Polach, 1991). Sea level in the equatorial Pacific exceeded pmsl by ~2 m in the mid-Holocene because of a variety of eustatic and regional tectonic factors (Dickinson, 2001; Allen, 2006). At this time, there was rapid flooding of the lower Sepik-Ramu basin.

The exact timing of the mid-Holocene highstand on the Sepik coast is uncertain but probably dates to ~7,000–5,000 BP, given both regional trends (Dickinson, 2001) and the abundance of uplifted coral terraces of this age along the northern coastline of New Guinea (Huon, Wewak, and Vanimo). This highstand may be reflected in the submergence of the Dongan shell midden ~5,700 BP, for the base of the midden is 0.5 m above pmsl and burial by marine mud occurs to a level of ~2 m above pmsl (Swadling et al., 1991; Swadling & Hope, 1992).

After ~4,000–3,000 BP, sea level began to fall to modern levels (Dickinson, 2001), and the Sepik-Ramu basin began to fill with alluvial sediment as river deltas formed and prograded seaward (Chappell, 1993a). The scant Holocene data from the Aitape trough (an east–west trending structural basin flanked by the Torricelli Mountains in the south and the Serra Hills in the north) are consistent with the history of the lower Sepik-Ramu, as both the Aitape skull site (Chapter 4) and our coring near Aitape in 1996 have produced evidence of mid-Holocene transgression flooding the Aitape trough ~7,000 BP. The discovery by Hossfeld of mid-Holocene estuarine sediments 12 km inland along the central axis of the trough suggests that this trough, like the Sepik-Ramu basin, was flooded far inland by the postglacial transgression.

Following from these observations, a hypothetical configuration of the coastline at ~7,000 BP is presented in Figure 3.3. The rapid postglacial rise in sea level of ~1 cm/year outpaced both sedimentation and uplift. As a consequence, much of the lower Aitape trough was probably inundated by the sea to form two shallow basins: an open bay in the west and a semienclosed embayment/lagoon in the east. The eastern lagoon was sheltered from the open sea by a chain of islands near what is today the town of Aitape (Fig. 3.1). Both basins were probably somewhat brackish (especially the eastern lagoon), given significant river inflow, and were probably not more than a few meters deep.

THIRD WORKING HYPOTHESIS—*In the late Holocene (~3,000–1,000 BP), continuing progradation of the shoreline led to the silting up of many of these former lagoons, and human settlement became focused ever more narrowly around the few remaining.*

After sea level stabilized and then began to drop to modern levels (4,000–3,000 BP), sedimentation outpaced sea-level change, and the shoreline started to migrate seaward. As the coastline advanced outward, extensive coastal swamps and estuaries probably formed adjacent to an open bay in the west and a largely enclosed lagoon in the east (Fig. 3.3). Judging from the history of the Sepik-Ramu basin, these two basins near Aitape and Sissano had probably silted in by 2,000 BP; additionally, the river levee and delta systems of the Bliri, Yalingi, and Raihu rivers had begun to develop and prograde seaward. An ancient meander belt of the Bliri River, probably less than 2,000 years old and still visible in satellite images, once flowed east of its current position near the modern village of Ramo (Fig. 3.1). The current meander belts and delta systems of these rivers are probably less than 1,000 years old.

This advancing process of progradation and infilling can still be observed today on this ever-changing coastline, where tall forest (average >30 m) with a fairly open canopy is dominant; as drainage deteriorates, sago palms enter into the undergrowth and become more common as the canopy becomes lower and more open (Haantjens et al., 1972, p. 31). Much of the present coastline in the Aitape area consists of sandy beaches up to 4 m high, forming a barrier bar along the prograding shores. There is a moderate net long-shore drift east to west driven by the onshore wind (trade winds). For about one-third of the distance between Aitape and Vanimo to the west, this barrier bar fronts lagoons or low-lying swamps.

The rest of the Sepik coastline is marked by rocky cliffs of 30-million-year-old volcanic rocks near Aitape and raised reef limestone directly southeast of Leitre; these rocky coastal stretches are places of rapid local tectonic uplift (Norvick & Hutchinson, 1980). The major present-day villages in the Aitape district are at Sissano and Malol lagoons (Fig. 3.1). Here an interconnected ecosystem of large and small lagoons has been the most favored location for present-day human settlement in the district (Goldsmith et al., 1999; McSaveney et al., 2000).

Analysis of satellite images confirms that present-day forest clearance and cultivation mostly occur on modern and ancient barrier beach and river levee systems (Pope, 2005). Key areas for use are where rivers (modern and ancient) enter Sissano Lagoon and where the river levees and beach ridge systems merge (e.g., river deltas).

Human Adaptive Strategies

Our field investigations since 1990 have shown us that people in this tectonically unstable coast have developed specific ways to handle the challenges of living in such a hazardous and changing environment (e.g., Tappin et al., 2008). One strategy we have been able to document is the

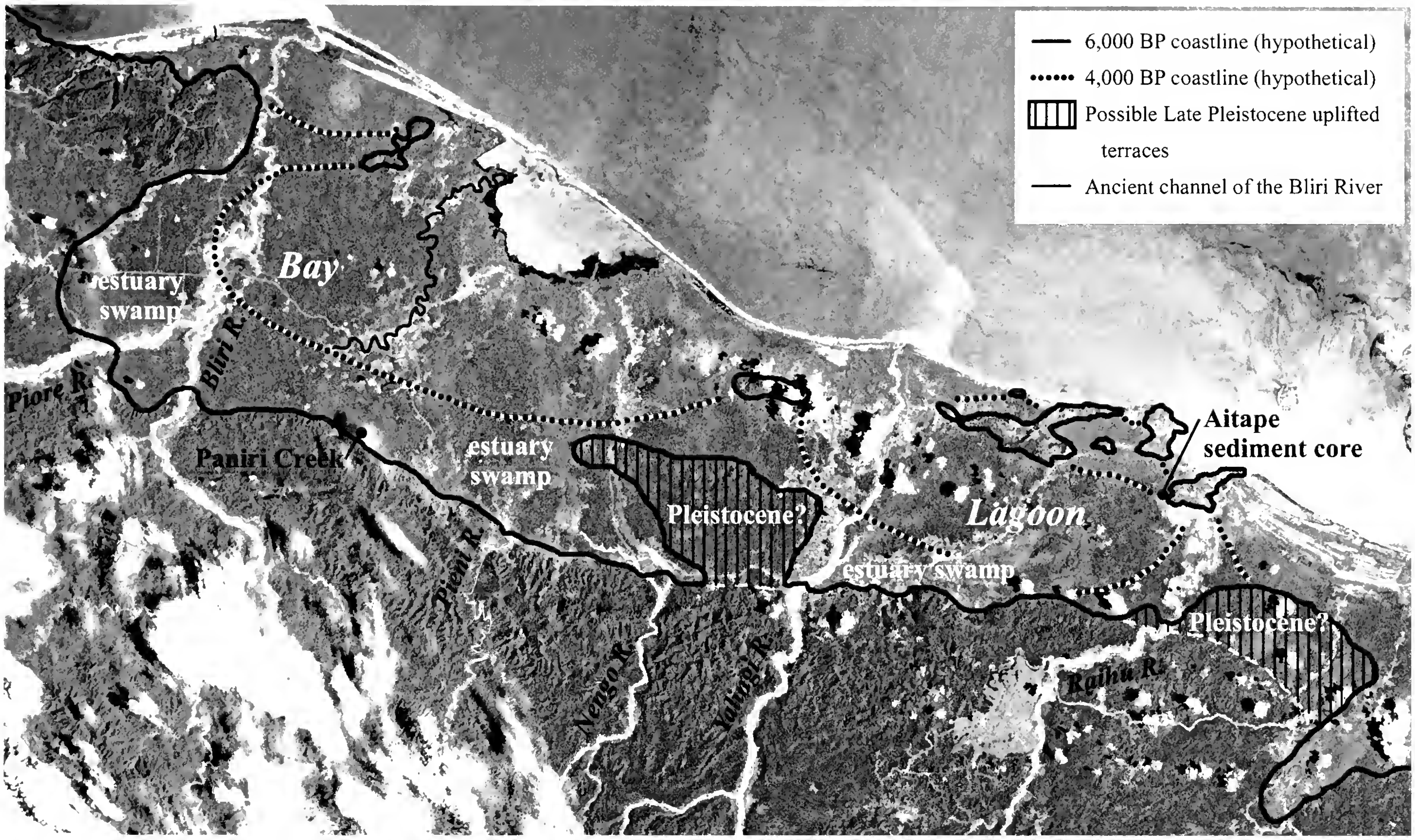

FIG. 3.3. LANDSAT ETM image (bands 5 4 3, RGB) of the West Sepik coast, Papua New Guinea, showing hypothetical coastlines at ~6,000 BP and ~4,000 BP. Note the formation of two distinct basins: bay in the west and lagoon in the east. Also shown are the locations of Paniri Creek, the Aitape sediment core, possible late Pleistocene uplifted terraces, and an ancient meandering channel of the Bliri River.

institution of inherited friendship (commonly referred to in the anthropological literature as "trade partnership"; Chapter 15). Another strategy, as yet still insufficiently documented for this coast, is the transgenerational management of resources.

Inherited Friendship

People on the Sepik coast maintain strategic long-distance alliances between individuals and families in different communities grounded on the practice of inheriting friendships in other places along the coast and on the small offshore islands. This well-established and widespread local institution joins families and communities living in different (and sometimes far distant) places along the coast into extensive human associations, or regional systems (Terrell, 1993), reaching far beyond the range of what anthropologists usually refer to as "face-to-face" communities. Comparable friendships also link people and places in the more interior reaches of these same coastal and offshore island communities (see Dobrin & Bashkow, 2006).

These friendships are a concrete example of what Alexander Lesser (1961, p. 43) once called social fields of "structured friendships." They are supported by widely shared ideas and expectations about how people ought to behave toward one another as friends; that is, the social institution that binds people in different communities on the coast and elsewhere together even though they may speak utterly different and unrelated languages is the custom of having friendships between families that have been handed down from one generation to the next.

Fieldwork on the impact of the tsunami of 1998 by Robert Welsch and Sebastine Haraha, a senior technical officer at the Papua New Guinea National Museum and Art Gallery, conducted in 1998, 1999, 2000, and 2001 at Arop, Warapu, and elsewhere on the Sepik coast has confirmed what has been noted by others elsewhere in Papua New Guinea: kin ties, trade partnerships, and friendships are well-established cumulative generational response mechanisms (i.e., social strategies and supporting social values) that facilitate giving aid, comfort, and assistance to those less fortunate following natural disasters (Waddell, 1975, 1989; Allen, 1989; Clarke, 1989; Wohlt, 1989).

Transgenerational Management of Resources

People on the Sepik coast invest time, labor, learning, and knowledge in planting, tending, and protecting a diverse array of species, most famously certain tree species (Kennedy & Clarke, 2004) that they know may take years, possibly generations, to mature and become available for harvesting. The pioneering investigations in the Pacific by the ethnobotanist Douglas Yen (1974, 1990, 1995, 1996) have brought the role of tree cropping in tropical subsistence systems, in particular, to the attention of many scholars (Gosden, 1995). Kyle Latinis (2000) has suggested that the term "agroforestry" can be used to refer to predominantly arboreal-based economies in which the transgenerational manipulation and maintenance of forest ecosystems and forest resources—including birds, reptiles, amphibians, insects, mammals, roots, grasses, leaves, and a wide range of medicinal plants—is central.

While other subsistence practices—for example, maritime-strand economies, intensive highland root-cropping economies, and the like—were probably also locally important in New Guinea in the past, just as they are today, it now seems likely that agroforestry has long played a dominant subsistence role in many parts of New Guinea and elsewhere in the western Pacific (Terrell, 2002; Kennedy & Clarke, 2004).

Latinis (1999, 2000) and others (Kennedy & Clarke, 2004) see the emergence of an emphasis on agroforestry as a broad regional phenomenon of great antiquity in Wallacea, New Guinea, and elsewhere in Oceania. As Latinis has observed in eastern Indonesia, there is

> a high degree of environmental management to maintain the practitioners' livelihoods and those of the future generations. Because forest resources, especially trees, often have long maturation rates, management practices involve a significant degree of long-term planning and stewardship. Furthermore, species introductions and replacements, as well as modifications to the overall spatial and temporal species/genera compositions, frequently occur. Although forest ecosystems are maintained over time, in fact, almost all exploited forest ecosystems have been at least partially modified. Likewise, single ecosystems do not compose the total resource environment, as a myriad of forest ecosystems and proximate non-forest ecosystems are targeted for exploitation. (Latinis, 2000, p. 43)

Implications

The observations and inferences presented in this chapter have several implications bearing on the broader prehistory of the Pacific Islands.

"Sleeping Giant" Hypothesis

Evidently, few people were living on the coasts of New Guinea Island during most of human time in this part of the world (Terrell, 2004a). In effect, earth and sea conspired to isolate this massive island, like a sleeping giant, from human contact with its neighbors for the first 25,000–35,000 years of human settlement in Oceania. To say that newcomers to the island always moved inland—thereby perhaps largely losing touch with the outside world—may be an exaggeration. But something like this must have happened repeatedly to people for literally thousands of years.

Furthermore, if this biogeographical hypothesis is correct, people living elsewhere in the Pacific would have also felt the impact of this giant's lengthy isolation during the Pleistocene and early Holocene. Before the mid-Holocene, many of the islands in the southwestern Pacific currently inhabited by people had been incorporated by the lowering of sea level into the two ancient continents usually labeled ancient "Sunda" and "Sahul" (Terrell, 2006). Two large archipelagoes, however, did survive as such even during the Pleistocene: one east and the other west of New Guinea Island.

It is probable that the arts of sailing, navigation, and island living that had been needed to reach New Guinea and Australia during the Pleistocene continued to be nurtured and improved in these two enduring island realms following their first human settlement. Between these archipelagoes, however, lay Sahul (New Guinea and Australia combined). If the lengthy northern shoreline of Sahul (i.e., what is now the island of New Guinea) was as steep and uninviting then as it often now is, this landscape must have been more of a vicariant barrier than a land bridge between these two ancient island worlds. If so, then geographical conditions favored divergence among prehistoric Pacific Islanders in their customs, speech, and physical appearance literally for many thousands of years, even granting that voyagers may have traveled west or east along the northern coastline of Sahul from time to time.

"Ancient Lagoons" Hypothesis

As already noted, by ~7,000 years ago, the earth's seas had risen to near present levels. By then, many coastal areas in the southwestern Pacific had probably started to develop into rich floodplains, river deltas, and lagoons. Coastal communities could now take advantage of the expanding stands of sago palms; they could exploit newly forming lagoons rich in fish and shellfish. Consequently, by the mid-Holocene, New Guinea's long isolation may have finally given way to new commerce and intercourse as coastal people began to travel and trade with greater reach (Terrell, 2002, 2004a, 2004b).

This second biogeographical hypothesis has a telling implication. According to standard ways of looking at the geographical patterning of human diversity in the Pacific, people who are labeled by linguists, archaeologists, journalists, biologists, and others as "Polynesians" or "Austronesians" started to arrive in the southwestern Pacific ~6,000 years ago (Terrell, 2009). Their successes where (presumably) others had earlier failed are generally attributed, as previously noted, to the invention of agriculture in Asia. An obvious flaw in this reconstruction, however, is that on present evidence, a major crop (rice) of subtropical Asian origin was not part of subsistence life of migrating Polynesians/Austronesians in the ancient Pacific, which on present evidence was based largely on local species of plants and animals, not foreign introductions (Diamond & Bellwood, 2003; Denham, 2004, 2006).

Said differently, based on what has been learned about settlement and subsistence in northern New Guinea and elsewhere in the southwestern Pacific, it now seems likely that nobody in prehistoric Oceania had to wait for the invention of rice agriculture in China to start looking for new places to live in Oceania after 6,000 BP. By the mid-Holocene, coastlines throughout the western Pacific may have become productive enough to support significant human populations, whether or not they had any strong commitment to food production. If so, then it was not the Neolithic Revolution but rather environmental change following the end of the Pleistocene that expanded the possibilities for coastal human settlement and thereby altered the ebb and flow of people from place to place.

Conclusion

Few would disagree with the idea that human beings can be agents of their own success or failure. However, we think strongly that it may be naive to see human prehistory simply as a story about increasing human mastery over and detachment from the natural world (Terrell et al., 2003; Terrell, 2006). What is now known or may be reasonably inferred about human prehistory in the Sepik-Ramu basin and on the Sepik coast adds tangible substance to the thought that it may be unwise to favor cultural determinism (in this instance, a so-called Neolithic Revolution) in situations where Mother Nature, in the guise of plate tectonics, geomorphology, and environmental change, has evidently had such a powerful role to play in patterning not only human settlement in northern New Guinea but also the character of human diversity elsewhere in the Pacific Islands.

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Chapter 4: History of Investigations

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Abstract

The northern half of New Guinea was the scene of major scientific field investigations prior to World War I. However, foreign interest in the Sepik region faded once the war in Europe had begun. Between the wars, Margaret Mead, Gregory Bateson, and others did notable work in the area, but coastal villages were largely ignored by anthropologists and others until the late 1980s. Even today, far too little has been documented about daily life and customs in villages on the Sepik coast. On the other hand, the collections-based research begun at the Field Museum of Natural History in the late 1980s together with several seasons of fieldwork at Aitape and elsewhere during the 1990s, as reported in this monograph, have helped clarify some of the parameters of human settlement and prehistory on this coastline.

Introduction

The Sepik River in northern Papua New Guinea flows roughly west to east for about 1,130 km before it reaches the Bismarck Sea. Artifacts from the Sepik began to reach foreign collectors and museums in some numbers by the 1870s. Germany gained political control of this part of New Guinea in 1884 (Firth, 1982). During the 30 years of their rule before World War I, German scientific expeditions collected extensively on the river and along the northern coastline of the island. During this same era, the Field Museum of Natural History sent one its first curators, Albert Buell Lewis (1867–1940), to the Pacific. Between 1909 and 1913, he visited New Guinea and neighboring islands with notebook and camera in hand while he was collecting examples of local art and craft for his fledgling museum back home in Chicago (Lewis, 1932; Welsch, 1998).

Although this island was the scene of major scientific work before World War I, foreign interest in the Sepik region faded once the war in Europe had begun. But then after the war during the years leading up to Hitler's rise to power and World War II, none other than the famed anthropologist Margaret Mead turned her attention from Samoa—where she had studied the lives of adolescent girls—to the Admiralty Islands and later northern New Guinea and the peoples of the Sepik River. However, the world was soon at war again, and, as the fates had it, northern New Guinea became a major battle zone during the ensuing struggles. War correspondents reporting on encounters there between Allied and Japanese forces made this island for a short while a household name throughout the world. But only for a short while.

When peace returned, anthropologists eventually came back to New Guinea, but the peoples and cultures of the Sepik River were no longer in the spotlight. Before the war, "lost tribes" had been discovered living in the lofty highland valleys set deep in the mountainous interior of the island. With peace, journalists and anthropologists alike were eager to discover more about these "last survivors of the Stone Age" who were then in the throes of abandoning their old ways in favor of presumably more healthful and efficient modern tools, goods, and services as the seemingly inevitable consequence of their growing contact with the modern world.

By the 1960s and 1970s, however, anthropologists finally began to trickle back to the Sepik, although by then it was hard for anyone who was not "working in the Highlands" to claim that they were witnessing ways and means untarnished by the modern outside world. One of the reasons scholars found themselves enticed back to the river was undoubtedly its enduring mystique among urban sophisticates in Europe and America as the source of quite desirable and collectible "primitive art."

Yet even now, unfortunately, far too little has been documented about daily life and customs in villages on the Sepik coast. The river and the coast may go by the same name, but they are separated from one another by mountains. True, as Mead was one of the first to report, there are traditional routes across the mountains between communities on both sides of this divide (Dobrin & Bashkow, 2006). But it was the art and customs of villagers in the river basin that attracted scholars after the war. Coastal villages were largely ignored by foreign scholars for decades.

Investigations

The Field Museum holds the largest ethnographic collection from Melanesia in the United States. About one-third of the Field Museum's holdings of approximately 38,000 objects from this region of the Pacific were obtained during the Joseph

N. Field South Pacific Expedition from 1909 to 1913 by Albert Lewis, who was at the time assistant curator of Melanesian ethnology. He had been trained by Franz Boas and had received his PhD in anthropology from Columbia University in 1906. Additionally, while in the field, Lewis took nearly 2,000 photographs of village life (Welsch, 1998). Nearly 1,600 of his original glass-plate negatives are still held in the Photographic Archive at the Museum.

In the late 1980s, Robert L. Welsch, a social anthropologist, and I initiated a research program at the Museum designed to document and explore the social, economic, and ritual diversity of communities on the Sepik coast of New Guinea Island using the Museum's ethnographic collections as a primary source of information. Before describing this research program, however, it is appropriate to review first what others had already accomplished in this same part of New Guinea before we ourselves made our first trip to Aitape in 1990.

The "Aitape Skull"

In 1929 a human cranium was found west of Aitape along the Paniri Creek 12 km inland from Sissano Lagoon at the base of the Barida Hills (Fenner, 1941; Hossfeld, 1949). For years thereafter, this cranium (most of the frontal bone and portions of both parietals), popularly known as the "Aitape skull," was thought to be Pleistocene in age. Because of the individual's apparent ruggedness, it was suspected that this find might be proof that *Homo erectus* had successfully crossed the Wallace Line east of Java. After World War II, however, this famous discovery was dated using radiocarbon to only ~5,000–6,000 years ago (Hossfeld, 1964, 1965). Restudy of the remains confirmed that this individual was modern in character, not *H. erectus*.

These cranial remains were discovered in association with well-preserved mollusca, foraminifera, organic matter, and sediments, attesting to a former intertidal environment—a scour deposit in a tidal mangrove swamp infilled with organic matter and sediments from both land and sea. This former swamp had been uplifted over the past 5,000–6,000 years to an altitude of 52 m above sea level: an averaged tectonic uplift for this area of the Sepik coast of around ~10 m per 1,000 years (Swadling & Hide, 2005).

In view of evidence for considerable uplift confirming that this is a tectonically highly active region and the co-occurrence of a mixed fauna of marine and estuarine shells and plant remains with human bone—associations similar to those in the sediments formed in Sissano Lagoon by the 1998 tsunami—the once famous "Aitape skull" may actually be from the earliest known tsunami victim found anywhere in the world.

Archaeological Investigations in the Sepik-Ramu River Basin

While the "Aitape skull" has disappeared from textbooks on human evolution, village communities in the drainage basin of the Sepik and Ramu rivers in northern New Guinea are still famous for being some of the most linguistically diverse people on earth. Staff from the Papua New Guinea (PNG) National Museum and Art Gallery in Port Moresby under the direction of Pamela Swadling began archaeological research along these rivers in the 1980s (Swadling et al., 1989, 1991; Swadling & Hope, 1992; Swadling, 1997). Their working premise was that the "current cultural diversity of the Sepik suggests a complex past" (Swadling, 1990, p. 71). They took it for granted, in other words, that "language groups at present provide the best means of examining the cultural diversity of the Sepik" (Swadling, 1990, p. 79).

Today this river basin is filled with swamps and broad floodplains. Prior to 6,000 BP, however, the earth's sea levels were well below their present highstand. In collaboration with John Chappell from the Department of Biogeography and Geomorphology at Australian National University, Swadling and her colleagues have shown that around 6,000 years ago, much of the Sepik-Ramu basin became flooded by the last marine transgression. Much of what had been a river basin became for millennia an inland sea (Swadling, 1997; Swadling et al., 2008).

Drilling logs kept during geological prospecting in the Sepik-Ramu basin reveal a complex geomorphologic history of the changing shorelines of this former sea. Swadling's working hypothesis was that "sediment studies around the edge of the Sepik-Ramu basin should reveal, as they did at the Aitape skull-fragments site, the former presence of intertidal mudflats, characterized by blue, sandy muds, carbonized wood, and marine and intertidal shellfish" (Swadling, 1990, p. 71). Following this logic, Swadling and her colleague Nick Araho from the National Museum discovered a shell midden in 1986 resting directly on recrystallized Pleistocene reef limestone under 3 m of river alluvium at Dongan, 17 km from the coast in the lower Ramu basin (Swadling et al., 1989, 1991). The midden was composed primarily of marine shells from mangrove and mudflat habitats, as well as fish bone from a number of marine species, and plant remains of what are currently important New Guinea tree crops (including *Canarium indicum* [canarium almonds] and *Cocos* sp. [coconut]).

They also found remarkably well-preserved marine shells in the bank of the Djom River, a tributary of the Ramu, 110 km inland. The Djom shells may date to the interglacial high sea levels of 120,000 years ago; the Dongan midden dates to around 5,800 radiocarbon years ago (Swadling, 1997, pp. 2, 6).

When the world's sea levels had risen again to within a meter or two of their present stand ~6,000–7,000 years ago, the inland Sepik sea was brackish and shallow (~3 m in depth). Its entrance at the coast was partially blocked by an island, now an area of low hills surrounded by swamp and coastal sediments. Where the great volume of freshwater discharged by the Sepik and Ramu rivers did not discourage their growth, there were mangrove stands and their associated fauna, including edible shellfish. With the gradual sediment infilling of the Sepik sea over time, the extent of these mangrove stands grew. By ~3,500 years ago, however, the sea was no longer brackish, and the coastline was prograding rapidly (Swadling, 1997, p. 5). Five midden sites located by Swadling and her colleagues on the eastern side of the lower Ramu River near Awar Lagoon have shown that people were fishing and gathering shellfish throughout much of this time. Obsidian flakes recovered from several of these middens attest also to long-distance trade with the Bismarck Archipelago east of New Guinea (Swadling & Hope, 1992, pp. 33–36).

During the existence of the Sepik sea and the smaller—but still sizable—freshwater lake that temporarily replaced it (vestiges of which still exist, e.g., the Chambri Lakes), communities in the basin would have had more direct access to people (and their products) in what are now the remote Highlands of New Guinea (Swadling & Hope, 1992, p. 37). Even when the inland sea was at its fullest extent around 6,500–7,500 years ago, however, people living around its shores would have been cut off from easy contact with people on the Sepik coast by the intervening northern mountain ranges, just as modern communities in the Sepik-Ramu basin are today.

Nonetheless, in light of its vast size and the richness of its flora and fauna (as attested by the middens excavated by Swadling and her colleagues), it is likely that the Sepik sea (and the large freshwater lagoons that temporarily replaced it) must have played a major role in determining the character of prehistoric interactions within and beyond northern New Guinea for much of the past 6,000 years, as Swadling (1997) has inferred. The infilling of the Sepik-Ramu basin, as she also argues, must have caused dramatic changes in how people lived their lives and may partially account for the complex patterns of migration and resettlement mentioned in local oral traditions (e.g., Tuzin, 1976; Roscoe, 1989).

Archaeological Investigations Near Vanimo, West Sepik Coast

In 1988 and 1989, Paul Gorecki surveyed archaeological sites on the Sepik coast between Leitre, Vanimo, and the Indonesian border. In June and July the following year, he conducted small excavations at three of the rock shelters (Itamesori, Taora, and Lachitu) he had located in the Musu-Fichin locality 18 km west of Vanimo (Gorecki et al., 1991; Gorecki, 1992).

These excavations suggested that there was a human presence on the coast ~35,000 years ago (Gosden, 1995, p. 810; Gorecki, pers. comm.) and established that the Lachitu shelter was being used at least by 17,350–16,150 years ago (13,940 ± 160 BP [ANU-7603, shell, corrected]), while the Taora shelter was first used sometime around 7,500–6,500 years ago (5,860 ± 90 BP [ANU-7606, charcoal] and 6,120 ± 190 BP [ANU-7605, shell, corrected]).

Most of the Taora deposit excavated was shell midden containing over 20 species that had been gathered from reef, rocky and sandy shore, beach, mangrove, and freshwater locations. That at Lachitu was a black organic-rich soil with some shell from a similar range of resource zones. Gorecki (Gorecki et al., 1991, pp. 121) suspects that there was a long hiatus between the Pleistocene use of Lachitu and its reuse starting around 6,400 years ago (5,610 ± 90 BP [ANU-7609, shell, corrected]). Faunal remains in both shelters were fragmented, but giant crabs, cuscus, lizards, snakes, fish, bandicoots, rats, wallabies, and tree kangaroos are attested.

While Gorecki was able to collect numerous surface finds of obsidian flakes during his 1988 and 1989 surveys, all considered to be from sources in the Bismarck Archipelago (Lou Island), he found little obsidian in stratigraphic contexts during his 1990 excavations (Gorecki et al., 1991, p. 119; Gorecki, pers. comm.). Most of the several thousand stone artifacts recovered were made from fine-grained chert thought to have been obtained from local limestone exposures (Gorecki et al., 1991, pp. 120, 121).

In 2004 and 2005, Sue O'Connor and colleagues from Australian National University, the PNG National Museum and Art Gallery, and the Australian Commonwealth Scientific and Industrial Research Organization carried out further excavations at Lachitu cave, and they also excavated at a new rock shelter site called Wathinglo west of Musu village. The work done at Wathinglo uncovered 3 m of shell midden deposits that may stretch back into the late Pleistocene. These investigations are as yet unreported.

Museum-Based Research

We were not the first to use museum collections from New Guinea Island to explore the patterning of cultural diversity on the Sepik coast.

Coastal Prehistory According to Frank Tiesler

A number of years ago, the German museum ethnologist Frank Tiesler (1969, 1970a, 1970b, 1975, 1984) suggested that trade and diffusion across cultural boundaries had long ago blended the disparate ethnic practices of resident Austronesian and non-Austronesian communities on the northern shores of New Guinea into a fairly uniform way of life no longer reflecting their formerly separate and divergent cultural pasts. In coming to this conclusion, Tiesler accepted the view then standard that this island has seen "specific waves of settlement," the earliest peopled by Papuan (non-Austronesian) speakers, the most recent (before modern times) by Austronesian speakers.

Tiesler further surmised that the non-Austronesian colonizers of this coast probably all originally shared basically the same cultural ways and inventory of things. Over time, however, this initial uniformity of culture must have given way to diversity because (he assumed) they had only simple dugout canoes, and their villages (he again assumed) were few and far between. Because of their inherent isolation from one another, in other words, Papuan-speaking villagers on this coast prior to the arrival of Austronesian speakers eventually developed into distinctly different local "cultural types." As he metaphorically expressed his understanding of what must have happened, each of these local Papuan cultures became "a separate stone" in the broad cultural "mosaic of the Sepik region" (Tiesler, 1969, p. 121).

But eventually Austronesian speakers arrived in the Pacific. They came (Tiesler surmised) with a technological innovation that radically altered the texture of life on the Sepik coast. They were skilled at making and sailing outrigger voyaging canoes. Their canoes made trade and travel along the coast easier, and, as a consequence, cultural diversity there declined. In its stead, a more uniform way of life came into being: a "mixed culture" testifying to a single and fairly cohesive "northern coastal cultural region." *Wir können mit Recht sagen, daß die Kultur jeder einzelnen Gruppe dieses Beziehungsgebietes zugleich Ausdruck der Leistung aller darin wohnenden Gruppen ist* (freely translated: "We can legitimately say that the culture of each group in this interconnected network of relationships reflects the achievements of all the groups living within the region"; Tiesler, 1969, p. 114).

In summary, Frank Tiesler more or less took it for granted that culture (and its manifestation as "material culture") had once been as diverse on the Sepik coast as language there still is today.

New Guinea Collections at the Field Museum

The Lewis Collection at the Museum is the largest (over 14,000 objects) and best-documented ethnographic collection ever assembled in the southwestern Pacific by a single field researcher. It also has better archival and photographic documentation than most museum collections made in Oceania before World War I (Welsch, 1998). Other important ethnographic collections from New Guinea now at the museum were assembled by Curator George A. Dorsey in 1908, by the plantation manager and field ethnologist Richard Parkinson between 1900 and 1908, and by Captain H. Voogdt, an employee of the Neu-Guinea Companie, in 1906–1908. In addition to these collections, the Museum also purchased a New Guinea collection in 1912 from J. F. G. Umlauff, a curio dealer in Hamburg, a large part of which had been collected by Captain Voogdt between 1906 and 1911 (Welsch, 2000).

A. B. Lewis Collection

Albert Lewis spent more time on the north coast of New Guinea than in any other part of Melanesia. He visited Humboldt Bay twice (1909 and 1912), spent nearly four months on the Aitape coast in 1909, visited the area between Wewak and Madang for nearly five months in the following year, and returned to Madang (then Friedrich Wilhelmshafen) in 1911 to ship much of his collection back to Chicago. Existing records on the Lewis Collection held at the Field Museum give basic information on materials used in an object's manufacture, its dimensions, place of manufacture, and place collected as well as Lewis's own general comments on form, style, and ornamentation.

The Lewis Collection was put together at a time when it was still routine for anthropologists to catalog similarities and differences in material culture methodically to define cultural relationships between local groups, tribes, and "primitive peoples." Taken together with other early information (e.g., Erdweg, 1902; Schlaginhaufen, 1910; Neuhauss, 1911; Friederici, 1912; Parkinson, 1979), this collection and its documentation (Welsch, 1998) serve as a cultural inventory benchmarking the diversity of local communities on the Sepik coast at the turn of the 20th century.

A. B. Lewis was impressed while he was living on the coast in 1909 and again in 1910 by the variety, amount, and geographic range of the exchange of foodstuffs (notably, sago and fish), raw materials, and handicrafts taking place among coastal, island, and interior communities speaking the many different Austronesian and Papuan languages on this coast. Prior to Lewis's journey to New Guinea, the famed ethnologist Richard Parkinson—building on preliminary observations by Otto Finsch—had already defined the "Berlinhafen Section" (i.e., the Aitape region) of the Sepik coast as a locality where communities all share fundamentally similar material culture traits as well as many similar customs, ritual practices, and the like (Parkinson, 1979), a theme that others have also voiced more recently (Tiesler, 1969, 1970a; Woichom, 1979; Barlow, 1985; Lipset, 1985; Lutkehaus, 1985; Barlow et al., 1986). Lewis was able to confirm Parkinson's assessment, and he found that this commonality of material and social culture—this *community of culture*—was achieved by complex exchange relationships between villagers on the coast. As he wrote back to his colleagues in Chicago:

> All the coastal region from Sissano to the neighborhood of Dallmannhafen [modern Wewak] must be regarded as of one general material culture with many minor variations from district to district, and even from village to village. In fact, the differences frequently seem to be greater than the resemblances. The islanders are the chief traders and travelers, so the islands show the most generalized culture. Many of the coast villages are very "local." (Welsch, 1998, p. 98)

Prior to our first field trip to this coast in 1990, we were already building a new integrated database on the collections at the museum from the Sepik coast (National Science Foundation Research grant BNS-8819618, "Trade Networks, Areal Integration, and Diversity along the North Coast of New Guinea: A Regional Analysis of the A. B. Lewis Collection at Field Museum of Natural History"). We were (1) assembling all available catalog, archival, and other documentary information on each object under study; (2) checking Lewis's original catalog records for accuracy and, if needed (and when possible), updating the information given using unpublished and published documents; (3) taking standardized photographs of each object in the collection; and (4) verifying and, if need be, refining object descriptions.

Results of This Initial Museum-Based Work

We found a lot of useful information on exchange between places on the Sepik coast in Lewis's field notes and diaries. Our new inventory of his collection also made it clear that many of the items he had obtained there had already been exchanged locally either as raw materials or as finished products before he purchased them. In short, a substantial part of his collection consists of objects made in one place on the coast but collected by Lewis elsewhere there. Because of the size of his collection, we were able to compile fairly detailed inventories of the sorts of objects used in and exchanged between separate (and often linguistically distinct) Sepik communities (Welsch & Terrell, 1998).

Thus, even before we went to this coast for the first time in 1990, we knew that communities there—despite their linguistic fragmentation—share much in common (Welsch & Terrell, 1991, 1998; Welsch et al., 1992; Terrell & Welsch, 1997). Some have questioned the significance of this observation (Chapter 2), but it is indisputable that museum collections at the Museum and in Europe confirm what Richard Parkinson (1979), A. B. Lewis, and others in the late 19th and early 20th centuries had reported. People on this coast (1) have a broadly similar material culture tool kit, (2) share other cultural practices and institutions, and (3) have unifying economic and sociopolitical arrangements while also having a few local specializations, too—notably in the production of certain handicrafts and other economically important items. As reported in Chapter 2, it is now clearer than it was at the beginning of our investigations that variation in what Lewis and others collected at different places along this coast is to some extent correlated with geography—specifically with the patterning of interactions among communities regardless of their linguistic differences.

1990 Reconnaissance

Our investigations on prehistory and human diversity of the Sepik coast have combined museum-based work with new field research. Robert Welsch and I first visited Aitape in April–May 1990 with funding from Walgreen Foundation to learn whether fieldwork there would be both possible and worthwhile. Richard Parkinson (1979, p. 18) had reported with considerable pessimism that traditional crafts were rapidly disappearing even in the 1890s. Similar pessimism about the persistence of older customs and practices on this coast had been raised by some of our own colleagues prior to our departure.

Once there, however, we soon found that many of the details of village life recorded by Lewis and others before World War I held true today (Welsch & Terrell, 1991). The social and economic ties joining people near and far together into a shared community of culture had survived two world wars, missionization, the introduction of money, modern roads, a cash economy, and, more recently, national independence. Moreover, traditional craft production continued to be an active part of life in every community. Surprisingly, aluminum pots and pans—as a case in point—had not eliminated the local demand for clay pots, although modern cookware did seem to have reduced the call for locally made pots and had made some types of pots less necessary for cooking vegetables and frying sago. Even so, earthenware pots for storing and turning sago starch into pudding were still in high demand, and such pots could be found in every hamlet.

This does not mean that nothing at all had happened between the start of the 20th century and our arrival in 1990. Craft production and exchange relationships had changed since Parkinson's and Lewis's time (Welsch & Terrell, 1991, 1998). Shell rings, ornaments, string bags, and soft Murik baskets, for example, no longer played a notable role in exchanges between people in different communities. But the direct exchange of sago, smoked fish, tobacco, betel nuts, clay pots, and other items remained an important component of the local economic networks mediating social relationships between these linguistically diverse communities. Moreover, traditional exchange relationships were still a vivid part of local knowledge in every village and hamlet we visited (Welsch & Terrell, 1991). We also learned everywhere that these relationships with other communities continued to be vital to an individual's sense of identity and understandings of the past.

In summary, we learned in 1990 that the local economy in the Aitape area is a complex set of relationships having obvious continuities with earlier exchange patterns as well as a variety of recent changes and modern innovations. We concluded that field research was needed to establish the form and frequency of interactions among different communities on the coast and determine how and why local socioeconomic patterns had changed yet still persisted over the many years in the 20th century between the time Lewis was there and our first trip.

1993–1994 A. B. Lewis Project

In the late 1980s, brief archaeological surveys were carried out by Pamela Swadling and Baiva Ivuyo around Aitape and Wewak on the Sepik coast and on the offshore islands of Tumleo, Kairiru, and Muschu (Pamela Swadling, pers. comm.). In 1993, with funding from the National Endowment for the Humanities (grant RO-22203-91, "Continuity and Change in Exchange Relations on the Aitape Coast of Papua New Guinea") and the National Science Foundation (grant DBS-9120301, "Exchange Networks on the North Coast of New Guinea"), Welsch and I carried out archaeological surveys in the area between the Serra (Serai) Hills west of Aitape and the town of Wewak east of Aitape (see Chapter 5) while also documenting the enduring social and economic networks of people in different communities on the coast.

1996 Archaeological Excavations

In 1996, with funding from the National Science Foundation (grant SBR-9506142, "The Archaeology of Exchange Networks"), we returned to carry out limited test excavations at Aitape and on Tumleo Island just off the Aitape coast (Chapter 6). At this time, preliminary subsurface coring at Aitape located a blue-gray clay stratum (probable lagoonal swamp clay; Chapter 3) at depths of about 3 m both at Aitape and at the base of the foothills inland. Woody material extracted from this layer has been dated by AMS assay to ~6,000–5,750 years ago (Beta-105207, 5,190 ± 40 BP).

Conclusion

The chapters in this monograph report in detail on our archaeological investigations on the Sepik coast and our laboratory analyses of the evidence recovered through survey work and excavation there. Additionally, Chapters 2, 8, and 9 describe our complementary research on the Museum's ethnographic collections of material culture from historic and modern communities on this coastline.

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Chapter 5: Archaeological Surveys

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Abstract

Between March 1993 and February 1994, archaeological site surveys were conducted in and around coastal and nearby offshore island communities in the area between the Serra Hills west of Aitape and the town of Wewak east of there. No excavations were carried out. Most of the surface collections made came from sites on Tendanye (Tarawai) and Walifu (Walis) islands off the coast of Wewak; Tumleo, Ali, Seleo, and Angel islands off the coast at Aitape; and the mainland Serra district west of Sissano Lagoon. We found an impressive diversity of previously unknown and unrecorded prehistoric pottery styles both locally in the Aitape and Tandanye-Walifu areas and along the entire coastal region surveyed. For both the Serra and Aitape areas, it was possible to use the evidence recovered to develop plausible ceramic sequences, and it can be argued that all the ceramic industries, extant and archaeological, now known for this coastal region are alike derived historically from the same red-slip tradition, which on present evidence was first established on Tumleo Island about 2,000 years ago.

Introduction

Between March 1993 and February 1994, Robert L. Welsch and I undertook an extensive dual program of field investigations on the anthropology and prehistory of the Sepik coast with major funding from the National Endowment for the Humanities and the National Science Foundation (Terrell & Welsch, 1997). Our ethnographic research documented in considerable detail how social, political, and economic ties among communities both near and far along this coastline are framed and supported by widely shared ideas, conventions, and expectations about how people ought to behave toward one another as friends (Welsch & Terrell, 1998). Working together with Wilfred Oltomo from the Papua New Guinea National Museum and Art Gallery in Port Moresby, we visited more than 80 villages in some 42 communities in Papua New Guinea and 11 villages in and around Jayapura in Indonesia. We made extensive collections of contemporary material culture items for both the Field Museum and the National Museum in nearly all these communities, with important collections from about 30 of them.

Our coordinated archaeological research was focused on field survey in and around the coastal and nearby offshore island communities we visited between the Serra Hills west of Aitape and the town of Wewak east of there. No excavations were done. We were assisted by Michael Reupana and Alois Kuaso from the University of Papua New Guinea for part of our time in the field as well as by members of the communities visited. In all, we recorded 121 collection areas (and find spots) and made surface collections of 10,771 potsherds, 1,432 obsidian flakes (1.517 kg), 25 chert flakes, 23 pieces of worked shell, 10 whole or fragmentary stone or shell adzes/axes, and a smaller number of other materials (beads, modern glass and ceramics, metal, and so on). Most of these finds were from sites on Tendanye (Tarawai) and Walifu (Walis) islands off the coast of Wewak; Tumleo, Ali, Seleo, and Angel islands off the coast at Aitape; and the mainland Serra district west of Sissano Lagoon (Table 5.1; see also Fig. 1.1).

Research Issues

We began our archaeological surveys in 1993 with six principal concerns in mind.

"Voyaging Corridor" Hypothesis

Geoffrey Irwin has suggested that New Guinea and the islands of Melanesia as far to the east as the Solomons once made up an ancient voyaging corridor between Southeast Asia and the Solomons (Irwin, 1991, 1992, pp. 5–6, 19, 1993, 2008; see also Irwin et al., 1990). He has characterized this corridor as an immense chain of intervisible islands sheltered equatorially between northern and southern bands of summer cyclones where there are seasonal (monsoonal) reversals of currents and winds. This set of circumstances made this area of the Pacific, in effect, a "nursery where prehistoric people learned the art of sailing successfully offshore with the security that there were many islands behind them to use as a safety net if anything went amiss" (Irwin et al., 1990, pp. 38–39). Therefore, Welsch and I wondered what sorts of archaeological evidence there might be on the Sepik coast testifying to ancient culture contact, trade, and possible settlement by

Table 5.1. Surface collections made on the Sepik coast in 1993.

Locality and site description	R&D[a]	Plain	Obsidian	Chert	Shell adze	Stone adze	Shell ring	Shell core	ABLP no.
Aitape									
Aiser garden site	138	344	1	3		1			615
Aiser garden site, back slope of the ridge	31	110		3					616
Uyopopao garden and house site	1	4		6					617
Sumalo Hill, location A	4	47							649a
Sumalo Hill, location B	86	457							649b
Sumalo Hill, location C	1	8							649c
Sumalo Hill, location D		4							649d
Sumalo Hill, location E	1	7							649e
Sumalo Hill, location F	2	11							649f
Sumalo Hill, location G	4	5							649g
Kiap Point, area A		3							650a
Kiap Point, area B	5	50							650b
Kiap Point, area C		6							650c
Kiap Point, area D		1							650d
Between kumu market and Sumalo Hill			8						650h
Locality subtotal	**273**	**1,057**	**9**	**12**	**0**	**1**	**0**	**0**	
Ali Island									
Mission area		2							119
Schoolchildren's collection			132						622
General			11						623
Haus Father, Mission grounds	1	16	4	1			1		624
Path from Haus Father to Aid Post			26						625
Area B			12						626
Caltaleo Hamlet			2						627
Ali Island, playing field area			7						628
Turale Hamlet		2	37						629
Aid Post, Haus Father and roadway	1	2	130						630
Aid Post and roadway adjacent		1	46						631
General		2	12						632
Etalal Hamlet	1	4							633
Turale Hamlet		10							634
Turale Hamlet (by beach)		1							635
Puyat Hamlet	1						1	1	636
Near Puyat Hamlet	1	3	12						637
La'ai, next to Caltaleo	2	15							638
John Sokar's house	3	16							639
Eitalol Hamlet		4	7						640
Area A (Tubungbale)	1	31	52						641
Area A-1	19	134	9						642
Area A-2	9	13	1						643
Area D (around Haus Father)	6	134	30						644
Area E	11	24	47						645
Malung Hamlet	24	67	19						646
Garden south of headquarters	1	10	1						647
Are (near Malung)	3	22						1	648
Locality subtotal	**84**	**513**	**597**	**1**	**0**	**0**	**2**	**2**	
Angel Island									
Chalsing ("Place No Good")	21	224						2	604
Sokolal clan land (collection area #1)	46	229		1				3	605
Locality subtotal	**67**	**453**	**0**	**1**	**0**	**0**	**0**	**5**	
Karesau Island									
Surface collection, approx. eastern one-half of island	4	34							195
Tera Hamlet—rise at center of the island		6	36			1			196
Wutwulin Hamlet								1	197
Tera Hamlet	11	96	1						198
Locality subtotal	**15**	**136**	**37**	**0**	**0**	**1**	**0**	**1**	
Kep (Kaiep) Village									
East end of the village	2	19							200
Locality subtotal	**2**	**19**	**0**	**0**	**0**	**0**	**0**	**0**	
Leitre									
Isi Village	6	63							601
Pino Village No. 2		22							602
Nowage Village No. 2	58	233							603
Locality subtotal	**64**	**318**	**0**	**0**	**0**	**0**	**0**	**0**	

TABLE 5.1. *Continued.*

Locality and site description	R&D[a]	Plain	Obsidian	Chert	Shell adze	Stone adze	Shell ring	Shell core	ABLP no.
Muschu Island									
Sup Village, Roman Catholic Mission grounds	77	230	1			1			183
Sup No. 2, Wanap land	35	121	2						184
Warag Village, children's collection	23	157							185
Warag Village, midden	11	73					1		186
Plantation trail, Warag to Pausum	1	12							187
Locality subtotal	**147**	**593**	**3**	**0**	**0**	**1**	**1**	**0**	
Ramu Village									
"Old Ramu," Taitoma land	71	112							156
"Old Ramu," Ovoiu land	2	42							157
"Old Ramu" (school yard), Kaitouru land	3	11							158
Locality subtotal	**76**	**165**	**0**	**0**	**0**	**0**	**0**	**0**	
Seleo Island									
Garden back of modern village, area A-1	10	145					1		159
Garden back of modern village, area A-2	12	96							159
Garden back of modern village, area A-3	21	102							159
Garden back of modern village, area A-4	13	58							159
Garden back of modern village farther back	62	18						2	159
Roman Catholic churchyard	88	268	14						160
Locality subtotal	**206**	**687**	**14**	**0**	**0**	**0**	**1**	**2**	
Serra									
Rainuk Airfield		8							120
Rainuk Airfield	1								121
Rainuk Airfield, roadway—west one-half	75	277				1			606
Rainuk Airfield, airfield and hangar area	16	79							607
Rainuk Airfield, roadway—east one-half	43	5							608
Rainuk Airfield, east one-half	67	192							609
Serai Village, riverside collection	5	38							610
Serai Village, inland side of the village	7	19							611
Serai Village, old roadway from the west	6	4							612
Peitol Rockshelter, exposed area just outside	12	82							613
Peitol Rockshelter, interior	12	23							614
Locality subtotal	**244**	**727**	**0**	**0**	**0**	**1**	**0**	**0**	
Sissano									
Sissano Airstrip	14	108							619
Porono locality (east end of Maindroin)	12	57							620
Maindroin Hamlet, general surface collection	6	32							621
Locality subtotal	**32**	**197**	**0**	**0**	**0**	**0**	**0**	**0**	
Suain District									
Lelap Hamlet	6	25							199
Locality subtotal	**6**	**25**	**0**	**0**	**0**	**0**	**0**	**0**	
Tandanye Island									
Wurat Hamlet	2	13							116
Sa'atem Hamlet								1	139
Sa'atem Hamlet		1							140
Nyamala Hamlet			2						141
Simirai (Simir rai) locality			1						142
Simir Rai locality			4						143
Leali locality			1						144
Ambachala locality	1	3							145
Sma Hamlet	9	2							146
Indobubu, 90 m of roadway, Collection A			11						147
Indobubu, garden at 106 paces from road			1						148
Indobubu, garden area, Collection B			2						149
Roadway between Indobubu and Sareta		2	20						150
Yundabubu (=Indobubu)		1	35						151
Munchika Community School	76	237	136				3	3	152
Munchika School, second area	49	185	1				2		153
Tawatohui, house area	27	121							154
Sareta garden site	24	176	17		1				155
Munchika, new garden area, Collection A	122	396	20						169
Munchika, new garden area, Collection B	35	112	3			1			170
Simindibubu garden area	88	268	170			1			171
Munchika, beach	3		16						172
Yundabubu garden area	2	5	86						173
Simir Rai garden			20						174
Sareta garden area	11	68	29						175

Table 5.1. *Continued.*

Locality and site description	R&D[a]	Plain	Obsidian	Chert	Shell adze	Stone adze	Shell ring	Shell core	ABLP no.
Modern hamlets	19	34							176
Locality subtotal	**468**	**1,624**	**575**	**0**	**1**	**2**	**5**	**4**	
Tumleo Island									
Ainamul Hamlet, house area	31	9							177
Wain locality	15	125		9					178
Mission Graveyard (Nyapin land)	147	69	31	1					179
Anilamo land, area 1	19	59				1			180
Anilamo land, area 2	7	74				1			181
General				1					182
Main road, Sapi hamlet			2						188
Locality subtotal	**219**	**336**	**33**	**11**	**0**	**2**	**0**	**0**	
Walifu Island									
Buamunding locality	144	556				1			161
Lakeba locality	196	599	13						162
Kambilal Hamlet, graveyard area	4	11							163a
Kambilal Hamlet, Kamambu area, ridge	33	290	143						163b
Kambilal Hamlet, Nyuminsom clan area	13	42	8						163c
Locality subtotal	**390**	**1,498**	**164**	**0**	**0**	**1**	**0**	**0**	
Totals	**2,423**	**8,348**	**1,432**	**25**	**1**	**9**	**9**	**14**	

[a] R&D = rim and decorated sherds.

people originally from elsewhere in this postulated voyaging corridor (Terrell, 1998).

Lapita and Austronesian Origins

Lapita is the name given to an ornate style of pottery found at a number of archaeological sites in Oceania (Terrell & Schechter, 2009). Sherds in this style have been unearthed on islands located in a broad arc of the southwestern Pacific running from Aitape on the Sepik coast all the way east to Fiji, Tonga, and Samoa (Green, 1994). It is generally held that this pottery tradition is the oldest in the Pacific. Some say it marks the arrival of Austronesian-speaking peoples in Oceania from somewhere in mainland Southeast Asia or Taiwan (Spriggs, 1997, 2007; but see Terrell, 2004). Given New Guinea's geographic location, many analysts have assumed that someday the missing link between Lapita pottery and early ceramics in Asia would be found somewhere along this coastline (e.g., Green, 1985, p. 220; Spriggs, 1996b, p. 339). As Patrick Kirch wrote in the late 1980s: "The search for Lapita origins must move westward along the unexplored north coast of New Guinea and into the Halmahera, Sulawesi, and southern Philippines region" (Kirch, 1988b, p. 336; see also Kirch, 1988a, pp. 158, 1997, p. 55).

Pre-Lapita Pottery?

We knew in 1993 that Pamela Swadling (Swadling et al., 1989; Swadling & Hope, 1992, p. 36) and Paul Gorecki (Gorecki et al., 1991; Gorecki, 1992) had argued—on the basis of their own previous archaeological work on this coast—that the art of pottery making in northern New Guinea might be as much as 2,000 years older than Lapita pottery in the Bismarck Archipelago. Yet we also knew that available radiocarbon determinations for early pottery, obsidian, and such like in the Sepik-Ramu basin and the Musu-Fichin (Vanimo) area of the coast had been challenged by other archaeologists (Spriggs, 1996a, 1996b, p. 329). While several of Swadling's carbon 14 dates could be used to infer that pottery arrived there around 5,500–5,600 radiocarbon years ago, one date (uncalibrated) on a composite charcoal sample of 3,280 ± 200 BP and another of 1,630 ± 120 BP had raised doubts about the true antiquity of the associated pottery and other artifacts she had recovered (Swadling et al., 1991, p. 106). Nonetheless, we felt that there was the prospect that regardless of whether we found Lapita on the Sepik coast, our survey might perhaps recover pottery older than Lapita.

An Evolving Landscape

Considering what Swadling and her colleagues had discovered about the changing shorelines of the former inland sea in the Sepik-Ramu basin (see Chapter 4), it seemed likely to us that this coast must have been a strikingly different place to live during the Pleistocene and early Holocene (see Chapter 3). Furthermore, we anticipated finding evidence confirming that over the past 6,000 years or so, this shoreline has been advancing northward: a slow process of progradation and infilling that can still be seen in action in the changing modern lagoonal systems behind the beaches at Malol, Sissano, Serra, and elsewhere. Moreover, we suspected that before stabilization of world sea levels around 6,000–7,000 years ago, there had been two different types of islands off the Aitape coast. Some were high and fairly steep and had been formed by the uplifting of former reef systems of Pliocene/Miocene age; others farther offshore made up flat, slightly elevated recent coral platforms (Haantjens, 1972). The latter are still extant and today are called the islands of Tumleo, Ali, and Seleo. The former, however, were eventually captured, or absorbed, over the past 5,000–6,000 years by the advancing northern New Guinea shoreline. These old upraised reef systems now form the steep hills around and to the west of Aitape.

Culture History

In their groundbreaking and remarkable monograph on traditional pottery making throughout Papua New Guinea, Patricia May and Margaret Tuckson (1982) describe the contemporary or recent practices of potters in a number of communities on New Guinea's northern coastline. By 1993, archaeological work had already been done in a few localities on the Sepik coast by Swadling and Paul Gorecki (see Chapter 4) and also farther to the east in the Madang and Huon Gulf areas by Brian Egloff (1975) and Ian Lilley (1986). Alas, however, none of this archaeological work had led to the definition of ceramic sequences useful for historical comparison (Lilley, 2004), and it was not clear in 1993 how today's pottery-producing communities might be related historically not only to one another but also to the ancient Lapita tradition found elsewhere in the southwestern Pacific. Welsch and I were interested, therefore, in learning how variable pottery assemblages are at archaeological sites along the Sepik coast and what were the prospects for chronological and comparative archaeological research.

Diversity and Interaction

We knew before we began our work in 1993 that Albert Lewis and his contemporaries (see Chapter 4) had found that people in different communities on the Sepik coast had been maintaining regular contact with one another, and that their visits back and forth had been marked by the exchange of material goods. These ties of friendship had been passed down from one generation to the next between people living in different communities who often spoke distinctly different languages. In spite of these language differences (see Chapter 2), however, we knew before we arrived in New Guinea that the things made and used by people in communities all along the coast had much in common—so much so that it was possible to say they all shared in more or less the same broad "community of culture" (Welsch et al., 1992, p. 590). Yet just as obvious, these ties had not led to the eradication of striking linguistic differences among communities on the coast. Did this lack of fit between language and material culture signal that social and economic ties between communities on the coast were only fairly recent and hence that contact between different communities has been too new to bring about language loss and abandonment? Or is there something about how people on this coast have interacted with one another that has tolerated, perhaps even encouraged, the persistence of linguistic diversity in the face of contact (Terrell, 2001)?

Archaeological Surveys

We undertook surface surveys in 1993–1994 in 15 localities along the coastline (Table 5.1). Because of the coastal and village-based orientation of our collaborative research program, only one inland rock shelter was visited (located in the foothills near the coast), and work on the inland coastal (Holocene) alluvial flats was restricted to the Aitape locality. In 1996, however, Glenn Summerhayes made a brief reconnaissance survey along the foothills overlooking Aitape (Figs. 5.26 and 5.27; see below).

In Tables 5.1–5.3 and in the following descriptive information about the localities explored in 1993–1994, the letters "ABLP" stand for "1993–1994 A. B. Lewis Project," and the associated numbers are taken from our field catalog listings. We used this numbering system both to label the things we bought for our two museums in Port Moresby and Chicago at the communities we visited and to catalog the archaeological surface collections we made during these visits.

The geographic coordinates provided here are derived from my field notes and the satellite imagery and coordinates available at http://earth.google.com. In instances where there is a discrepancy between the location names given by Google Earth or by the online databases "Directory of Cities, Towns, and Regions in Papua New Guinea" (http://www.fallingrain.com/world/PP) and "World Wide Index" (http://www.tageo.com), preference has been given to information we collected in the field available in my field notes.

Western Coast

Leitre—While at Vanimo seeking final government approval for our project from the West Sepik (Sandaun) Provincial Government, Welsch and Oltomo visited the hamlets of Isi (ABLP 601), Pino No. 1 (ABLP 602), and Nowage No. 2 (ABLP 603) in the coastal Leitre locality (−2.833° latitude in decimal degrees, 141.633° longitude) east of Vanimo. People living in this area speak the non-Austronesian Rawo language assigned by linguists to the Sko language family.

Welsch and Oltomo made small surface collections of pottery sherds at several locations near the shoreline at Leitre (Figs. 5.1 and 5.2). Given the geomorphological location and the circumstances of recovery, it is unlikely that these sherds are of much antiquity, nor is their stylistic appearance notably distinctive. However, these sherds have proven useful for petrographic and trace element characterization of ceramic variation along the Sepik coast (Chapters 12 and 13). Additionally, Welsch and Oltomo obtained local potter's temper sand (ABLP 344), a potter's raw clay sample (ABLP 343), and strips of prepared potting clay already mixed with this sand (ABLP 345–346) from Mrs. Nuina Sinene, a local potter at Nowage Village. These materials have also proven useful for the same reason.

The surface finds from ABLP 603 (Nowage No. 2) show that red (clay) surface slipping has been characteristic of at least some pottery in this locality on the Sepik coast. One of the potsherds (603-1) examined by William Dickinson (Chapter 12) does not group well with any of the other specimens he has studied from this coast, and it appears to have been made from a naturally tempered ashy soil rich in juvenile tephra (for further discussion, see Chapters 12 and 13).

Serra—Surface collections were made at the back of the modern beachfront village of Serra (−2.968°, 141.945°), also known as Serai, between the village area and the coastal road running more or less parallel to the shoreline (ABLP 610–612). Somewhat larger and more informative collections (ABLP 606–609) were obtained from the cleared ground of a newly bulldozed roadway running along the landing strip at Rainuk Airfield (−2.973°, 141.930°) located 1.4 km west of Serra. This airfield is approximately 0.95 km long and roughly parallels the coastline about 0.6 km back from the beach. Collection ABLP 606 comes from approximately the western one-half of the roadway and southern edge of the airfield, ABLP 607 is from around the passenger hangar on the landing strip, ABLP 608 is a selective surface collection from the eastern one-half of the field, and ABLP 609 comes from the roadway and the eastern end of the landing strip itself.

Accompanied by Peter Maintau, the landowner, and Martin Sapien from Serra Village, we also traveled by dugout canoe on the water channels of the extensive but quite irregularly shaped coastal lagoon between Rainuk and Serra to examine

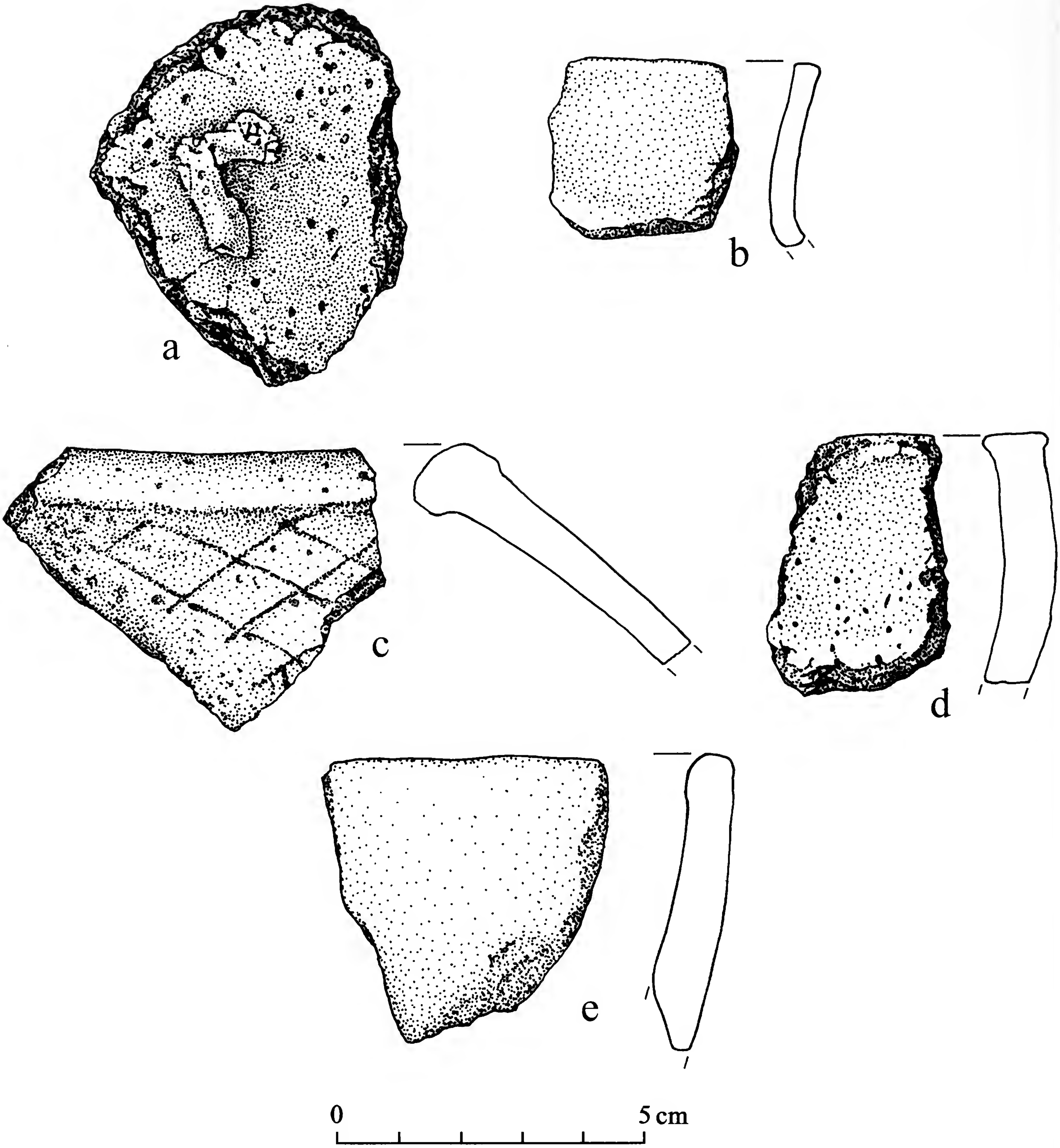

FIG. 5.1. Selected examples of the sherds collected at Isi Hamlet, ABLP 601, Leitre.

Peitol (approx. −2.991°, 141.929°), a small rock shelter (ABLP 613–614). This rock shelter, which Maintau said had been used as a place of refuge during World War II, is at the base of the coastal foothills roughly 2.0 km inland from the airfield.

In addition, we collected samples of potter's clay from source locations that Peter Maintau said are used by local potters.

SERRA (SERAI) VILLAGE—Three small surface collections were made behind this modern village. ABLP 610 (approx. −2.969°, 141.947°) is a scattered surface collection from cleared garden land on the south side of the roadway behind the village on its eastern side near the mouth of the local river (lagoon outlet). ABLP 611 is a collection of sherds picked up all along the southern (inland) side of the village. ABLP 612, made up of only 10 sherds, is from an older roadway leading into the village on its western side; six of these are body sherds with exterior wavy scoring on the surface. Decorative techniques attested in these collections are red (clay) filming (slip) as well as wavy scoring, rims that are plain and

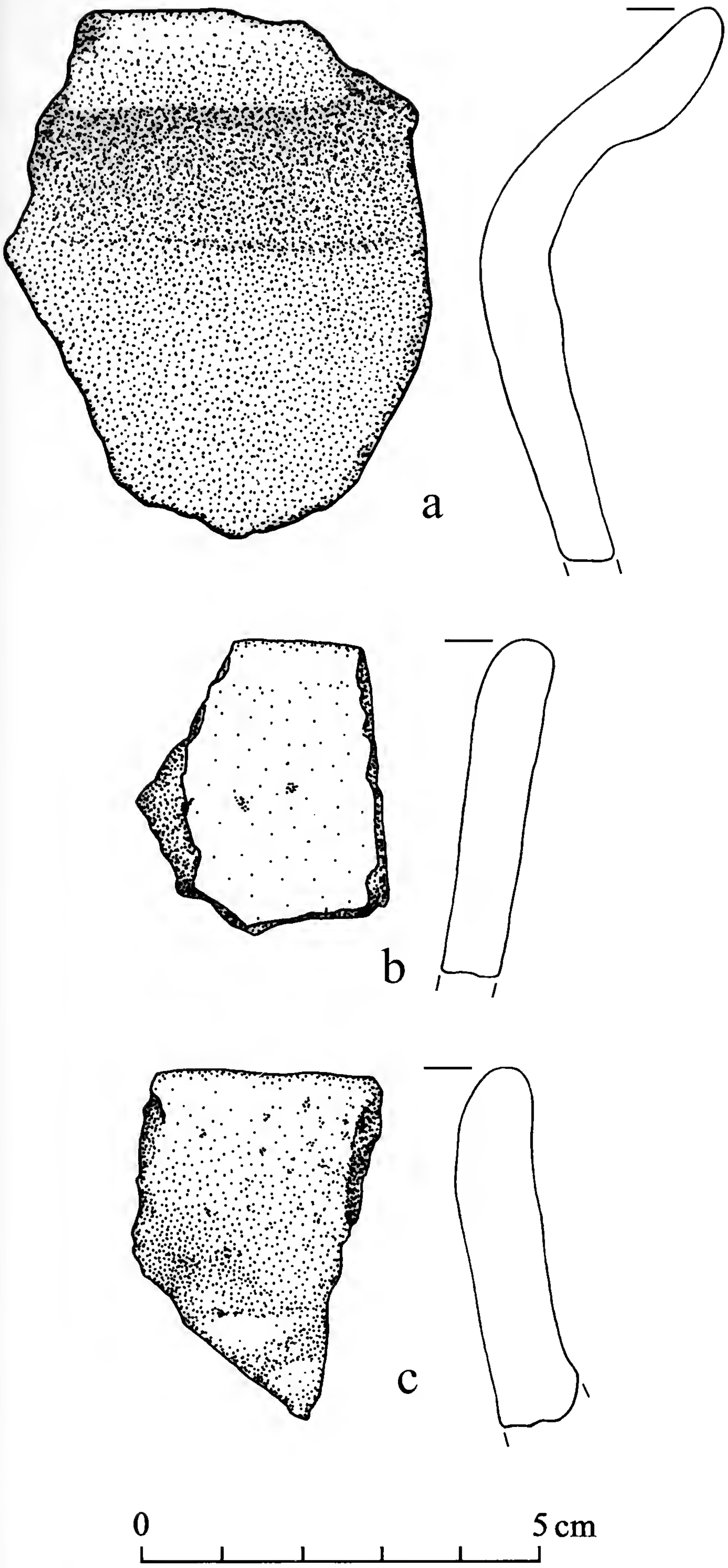

FIG. 5.2. Sherds from Nowage No. 2, ABLP 603, Leitre.

unnotched, and shapes that include everted rim vessels and ceramic dishes or pans presumably used (as such are today) for frying sago starch.

RAINUK AIRFIELD—Informative surface collections were made in the bulldozed roadway that had been newly cut along the inland (southern) side of the airfield near Rainuk Village west of Serra as well as along the southern side of the runway itself. ABLP 606 comes from the western end of the airfield: an area of land (and evidently former village location) traditionally called Sagilau. Coiling is attested as a potter's technique (Fig. 5.3b), and vessel shapes include small bowls with inverted and open rims having simple rounded lips as well as sago frying pans also with simple rounded lips (Fig. 5.3a–c).

Decorative techniques evidenced include red filming (clay slip) as well as punctation and scoring, both linear and wavy, using double- and triple-pronged "toothed" implements of some description. Included in the collection obtained are several sherds of Wain Ware (Fig. 5.15 and Chapter 7), one of which (Fig. 5.3f, sherd SR6069, Aitape-Barida 1 in Appendix 13.3) has been sourced directly to the Aitape ceramic tradition (Chapter 13).

ABLP 607 is a small collection from the airstrip and area immediately around the passenger hangar. Attested again are simple rounded lips, simple open everted bowls and sago frying pans, as well as incising, punctation, and scoring—the latter possibly done with a triple-pronged tool. ABLP 608 is a selective surface collection from the eastern half of the roadway beside the airstrip at a locality called Nyampe, evidently a former village site. In evidence is a rich diversity of incised, punctate, and scored design attributes (Figs. 5.4 and 5.5) done with a range of multiple-pronged or toothed tools. A Wain Ware sherd in the collection, one that is rather weathered, has been sourced directly to the Tumleo tradition (Fig. 5.4b, sherd SR60813). Finally, the last collection made at the airfield (ABLP 609) comes from the eastern end of the airstrip and the ground between there and the roadway. Red film (clay slip) is in evidence, as is lip notching, punctation done with a double-pronged tool, and diagonal incising just below the exterior lip edge (Fig. 5.6).

PEITOL ROCKSHELTER—This is a small overhanging rock shelter approximately 14 m wide and 5 m deep. ABLP 613 is a surface collection from the area just outside this shelter that had been recently bulldozed by a foreign logging company working in the Serra area; ABLP 614 comes from inside the shelter itself. All the sherds collected in both areas are fairly nondescript, but they document the use of coiling as a potter's technique as well as red filming (clay slip), decorative wavy scoring of the exterior of vessels using a three-pronged "comb" or toothed implement, and vessel shapes that include pots with simple everted rims as well as shallow ceramic plates or pans for frying sago having simple unnotched rims (lip edges). One flat-lipped sherd is possibly a Wain Ware vessel imported from the Aitape area.

CLAY SAMPLES—Five clay samples (see Chapter 13) were collected along with a sample (ABLP 192) of beach sand from the shoreline at Serra, an Austronesian-speaking village. ABLP 189 is a sample of potter's clay (*bepaik*) given to us by Teko and Suware Ekaro, two sisters who are potters at Puindu Hamlet (−2.973°, 141.905°); it derives from a source locality called Suma (described as a low "mountain" west of Puindu). They demonstrated for us how they make pots using coiling rather than paddle-and-anvil techniques. Samples ABLP 190a–190c and 191 were collected with Peter Maintau on land belonging to him and his family (Ainip clan) near Peitol when we visiting Peitol Rockshelter with him. ABLP 190a was removed by Maintau from an established potter's clay pit that had recently been disturbed by bulldozing associated with foreign commercial logging. ABLP 190b was an additional sample removed from the bed of the dozer cut by Welsch several feet away from ABLP 190a. Similarly, ABLP 190c came from near the traditional clay pit and was collected also by Welsch. ABLP 191 was removed from a new clay source being used by Maintau's mother located northeast of ABLP 190a–190c from ground adjacent to the land traditionally called Peitol.

GENERAL OBSERVATIONS—There is a long narrow water channel on the (southern) side of the roadway at Rainuk

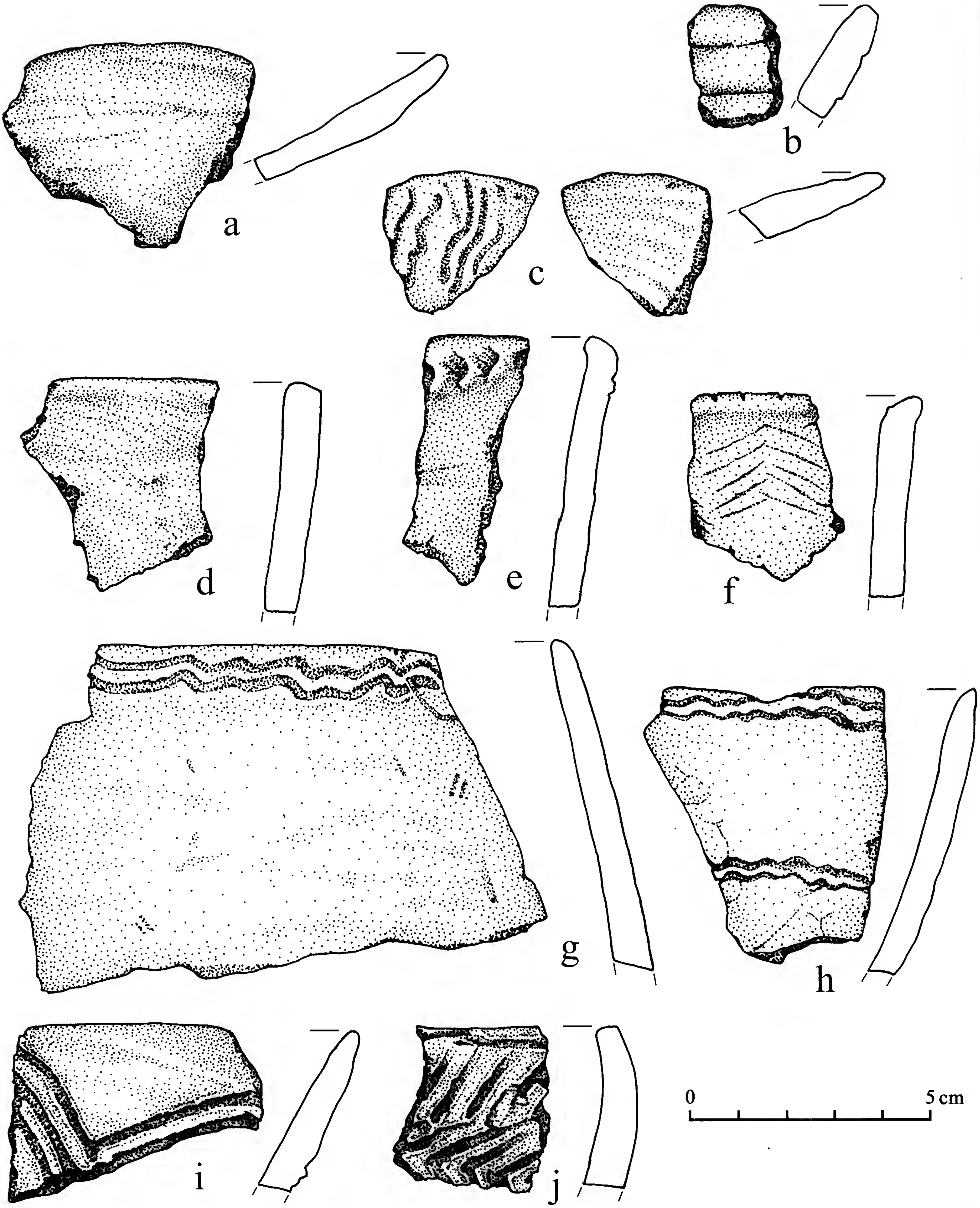

Fig. 5.3. Rainuk Airfield, ABLP 606, Serra (606**f** is a Wain-style sherd chemically sourced as probably coming from the Aitape ceramic tradition; sherd SR6069, Appendix 13.3).

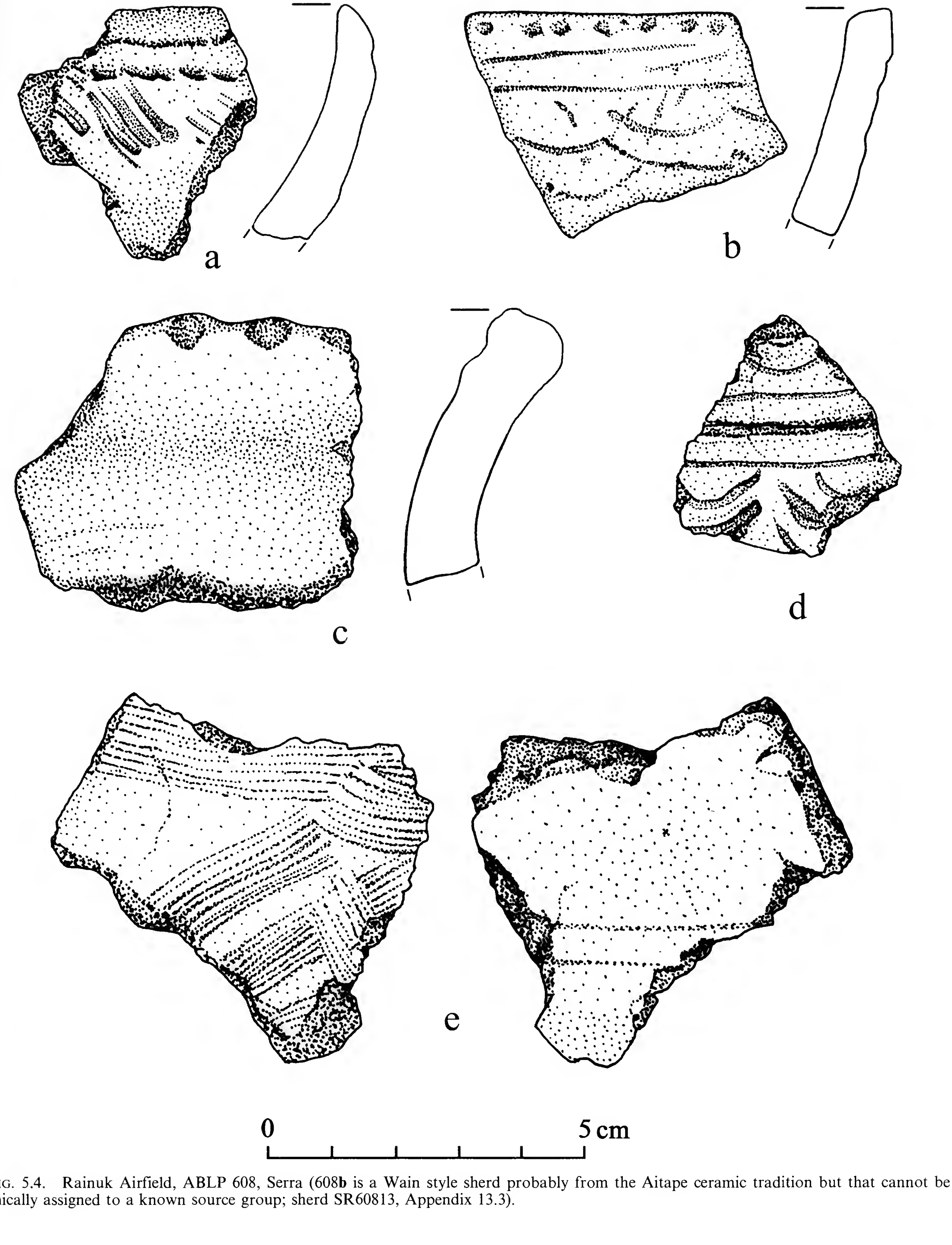

FIG. 5.4. Rainuk Airfield, ABLP 608, Serra (608**b** is a Wain style sherd probably from the Aitape ceramic tradition but that cannot be chemically assigned to a known source group; sherd SR60813, Appendix 13.3).

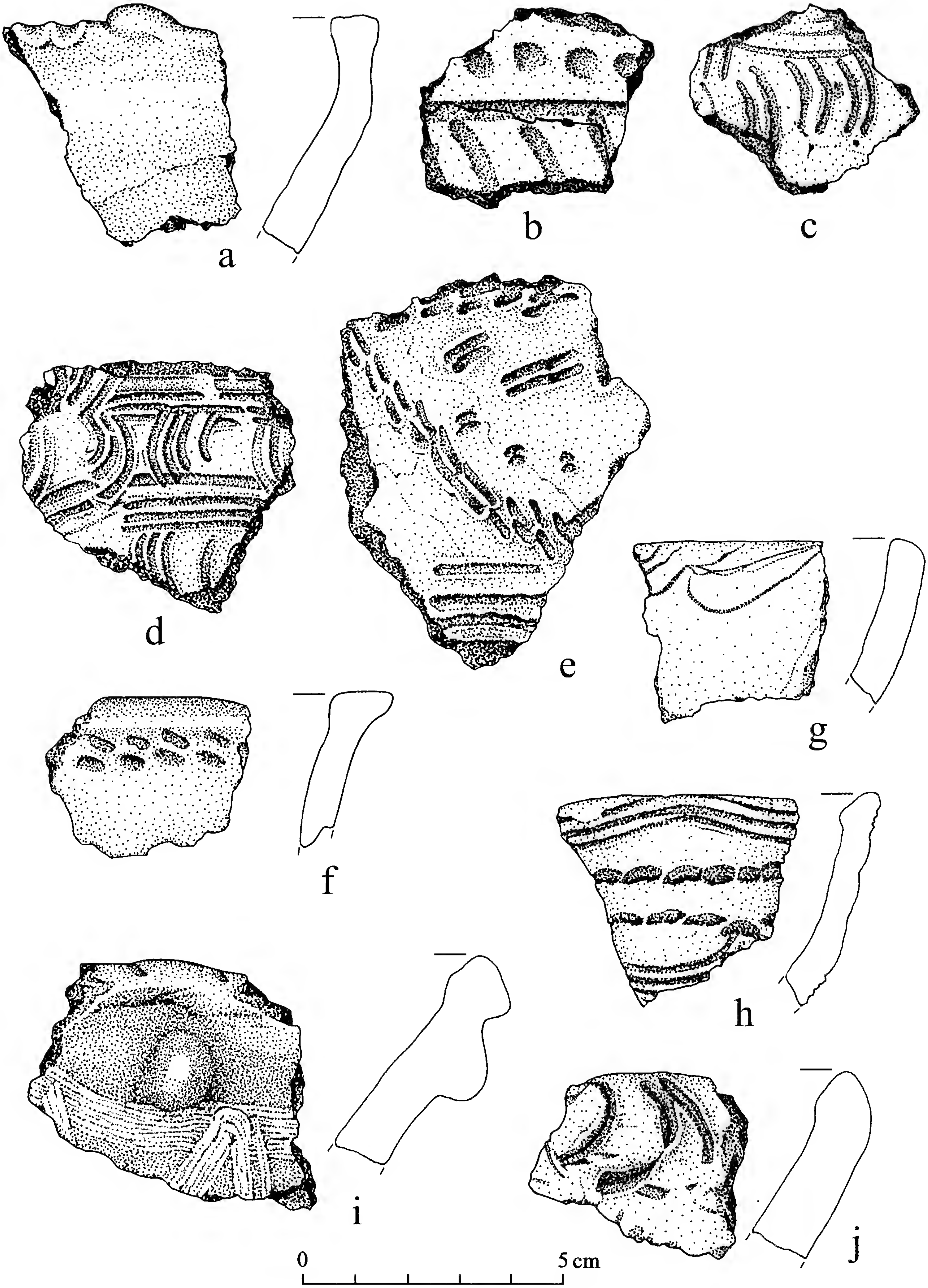

FIG. 5.5. Rainuk Airfield, ABLP 608, Serra.

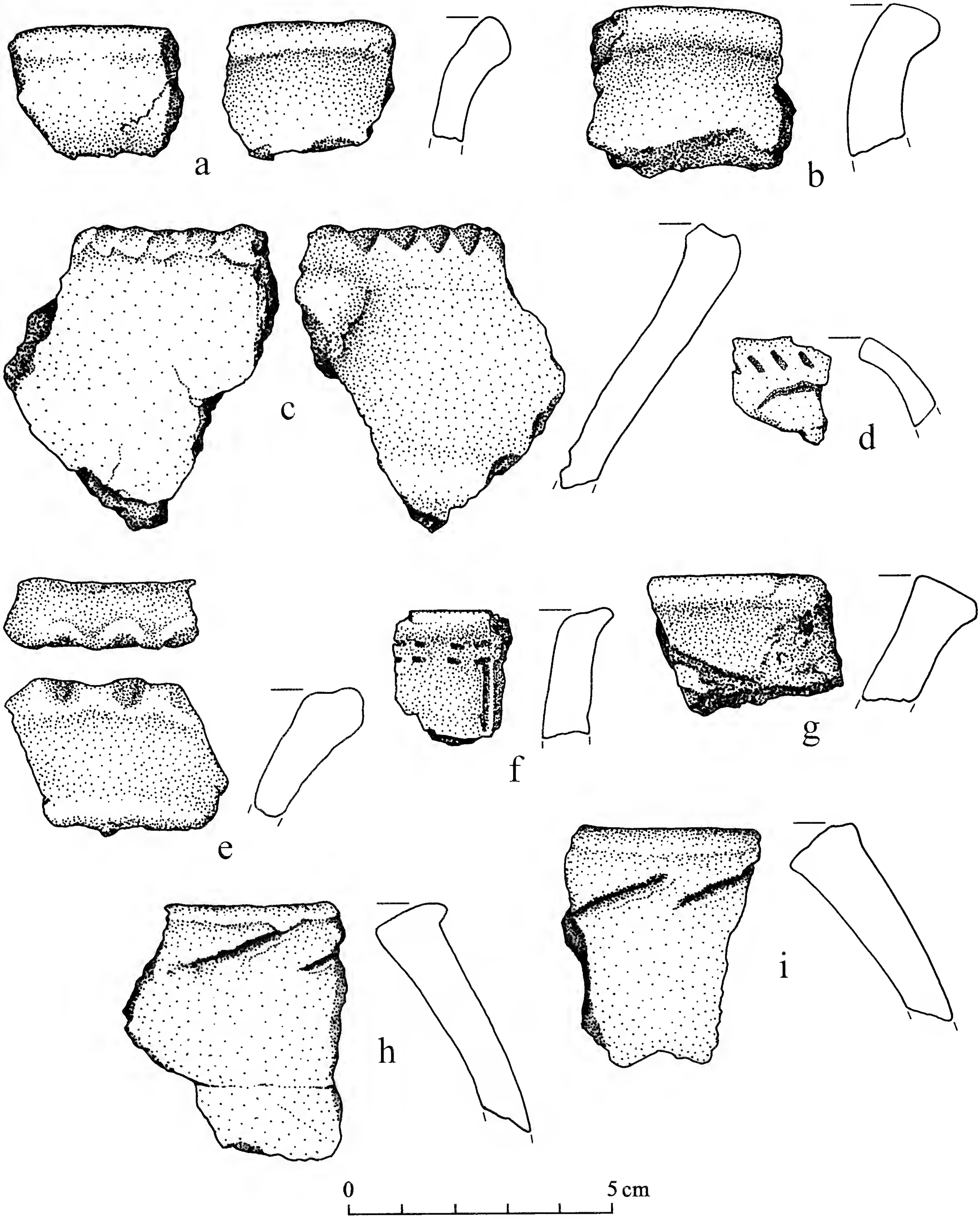

FIG. 5.6. Rainuk Airfield, ABLP 609, Serra.

TABLE 5.2. Proposed spatial seriation of the surface collections made at Rainuk Airfield, Serra.

Proposed chronology	Collection
Modern and historic Serra pottery	—
Sagilau pottery	ABLP 606 and 607
Later Nyampe pottery	ABLP 608
Earlier Nyampe pottery	ABLP 609

paralleling the shoreline. Both the runway of the airfield and this recently bulldozed roadway were, in effect, an excavated transect along the shoreline of this narrow water channel (which opens up farther back from the coast into a small and irregularly shaped lagoon). Here and there along the shores of this lagoon are tall wooden house posts that, according to Peter Maintau, are all that now remains of a former men's house and other buildings marking a previous village site in use before the community there moved down to the beachfront locations of the present-day Serra hamlets. It is not known whether this relocation was before or after World War II.

On the basis of the collections made in 1993, it is apparent that pottery from the Serra area has a number of distinguishing characteristics. The evident method of manufacture favored (coiling) suggests historical ties with other pottery-making communities in the Vanimo and Leitre localities to the west based on both our field observations and on what May and Tuckson (1982, pp. 316–317) have reported. It also seems likely that the observable stylistic differences between the several collections made along the bulldozed "roadway transect" at Rainuk Airfield are chronological, perhaps as seriated in Table 5.2.

The association of ABLP 606 and 608 with sherds of Wain Ware from the Aitape area 55 km to the east suggests that Nyampe and Sagilau pottery dates to sometime in the latter half of the second millennium AD, but since Wain Ware is itself still poorly dated (Chapter 6), there is currently little basis to speculate further about the antiquity of these ceramic surface collections.

Aitape District

SISSANO—Rob Welsch and I first visited the lagoonal communities of Sissano (−3.001°, 142.0048°) and Warapu (−3.013°, 142.075°) in 1990. We revisited both several times in 1993–1994. Warapu was completely destroyed, and parts of Sissano were heavily damaged by the tsunami of 17 July 1998. ABLP 619 is a surface collection from the eastern end of the airfield at Sissano. ABLP 619 is from the land called Porono at the eastern end of Maindroin Hamlet at Sissano Village; ABLP 620 is a small surface collection from here and there at Maindroin. All three collections included plain unnotched rim sherds from what were probably sago frying pans. Also present were everted rim sherds, incised sherds, and one with wavy scoring. No evidence of red surface filming (clay slip) was found.

RAMU—Ramu Village (−3.093°, 142.027°) is on the coastal alluvial plain 10.25 km inland from the shoreline at Sissano Lagoon. Poura, or "Old Ramu" (−3.092°, 142.026°), on the west side of the present-day village approximately 0.2 km away from the central pathway running north to south through the village was being used in 1993 as garden land. We were told that the community had moved from Poura (or Foura) to Ramu on the advice of a government official who told them the new location would be a healthier place to live. No one we spoke with was clear about when this move had occurred.

ABLP 156 is a collection from garden land belonging to the Taitoma clan at Ramu; ABLP 157 is a collection from the adjacent roadway nearby that runs west from Ramu to Sumo Village approximately 8 km away. The roadway at that point runs through land associated with the Ovoiu clan. ABLP 158 comes from around the village school at the southern end of Ramu on land identified with the Kaito'uru clan.

The sherds collected in these three locations appear to come from bowls and sago frying pans made using coiling with simple direct or (less commonly) slightly everted rims, unnotched lips, no red film (clay slip), and little in the way of decoration except occasionally some simple linear incising (and, in one instance, a simple appliqué band; Fig. 5.7d). Also found was a blue glass bead, numerous lagoon and mangrove shells, a rusted iron object of indeterminate form, and an oval, lenticular boulder of sandstone 17.0 × 13.5 × 3.2 cm with six deep and also numerous shallow striations indicating probable use as a block for sharpening stone tools.

AISER—In October 1993 Dennis Moipo from Wom, an inland village on the main road that runs to the southwest out of Aitape, reported to us that he had discovered pottery sherds while working in his garden at a locality near Wom called Aiser (−3.202°, 142.242°). Shortly thereafter, he brought us a sample of what he was finding. We then visited the site with Dennis and Jack Sabokai from Wom. According to Jack, the place where Dennis had his garden was not known at Wom as a former village location.

The site is a steeply sloping hillock on the very edge of the foothills that rise out of the alluvial plain behind Aitape (which is thought to have formerly been a more or less open coastal lagoon; Chapter 3). Most of the pottery sherds we collected came from the sloping ground below the hill top (ABLP 615); little was found on the ridge itself. A small number of sherds were also picked up on the back side of the hillock (ABLP 616), but collecting conditions were less favorable there.

Much of the ceramic material recovered at Aiser strongly resembles comparable material excavated in 1996 on Tumleo Island (Chapter 7)—in particular the decorated rim sherds shown in Figure 5.8. Given that the Aiser finds were discovered first, we consider this locality to be the type site for what we have named Aiser Ware. However, there are several clearly observable differences between Aiser Ware from Tumleo and this comparable material from Aiser. The globular vessel shape and rim form shown in Figure 5.8a have no close parallels among our Tumleo finds. The decorated flat rims shown in Figure 5.9a–b are also seemingly missing from Tumleo. Similarly, the appliqué and punctate appliqué band design motifs shown in Figure 5.10 are more elaborate than their Tumleo counterparts. Finally, there are some design characteristics (Figs. 5.9a–b, i, and 5.10a) that arguably also foreshadow some of the design characteristics of Wain Ware. These differences appear to be sufficient to hypothesize that future research will show that the Aiser Ware finds from the type site of Aiser come from a production center other than Tumleo Island, possibly from a place of manufacture somewhere on the mainland in this part of the Sepik coast. It also seems likely that Aiser may have been occupied at a time when Aiser Ware was starting to acquire certain design

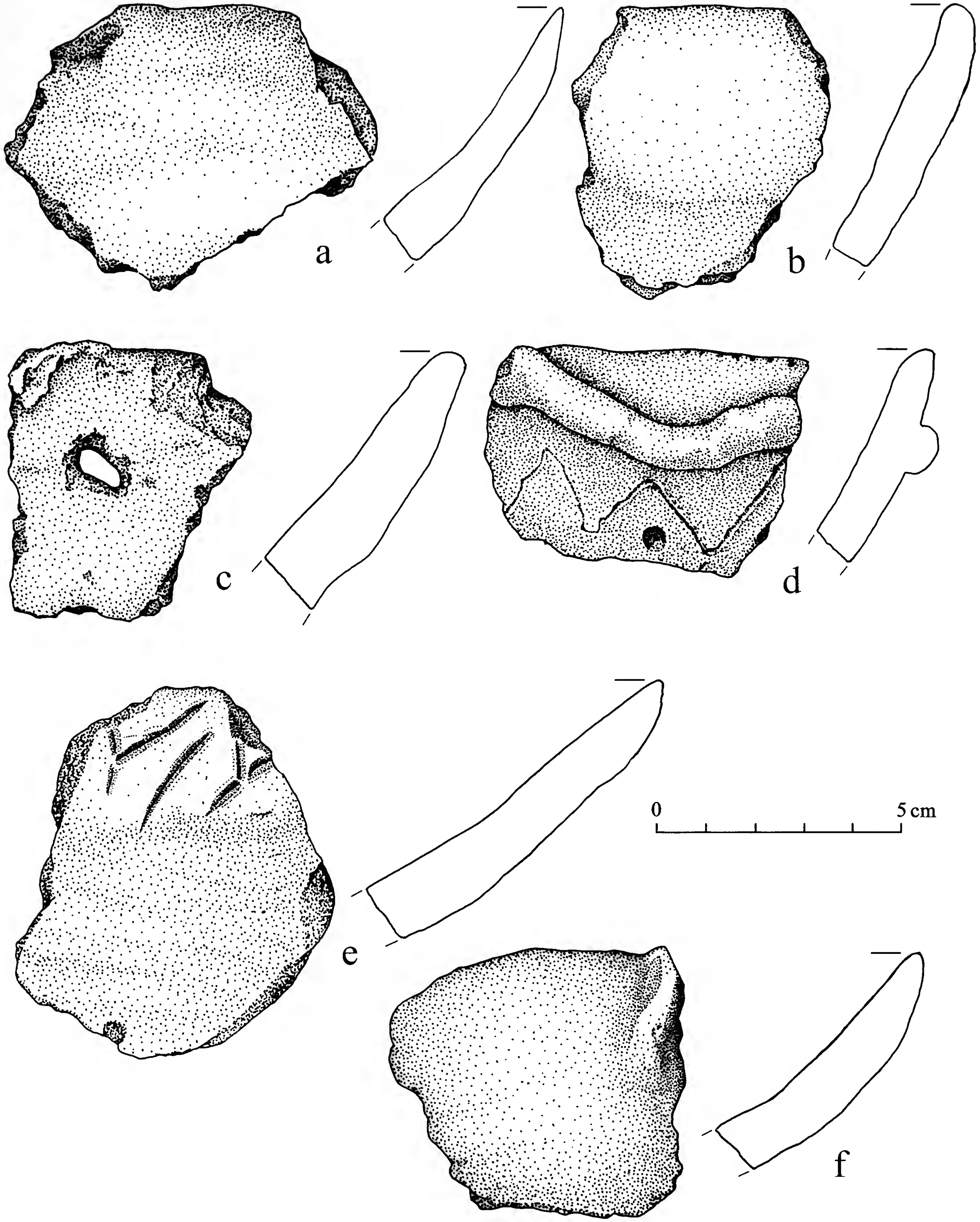

FIG. 5.7. Old Ramu, ABLP 156, Ramu.

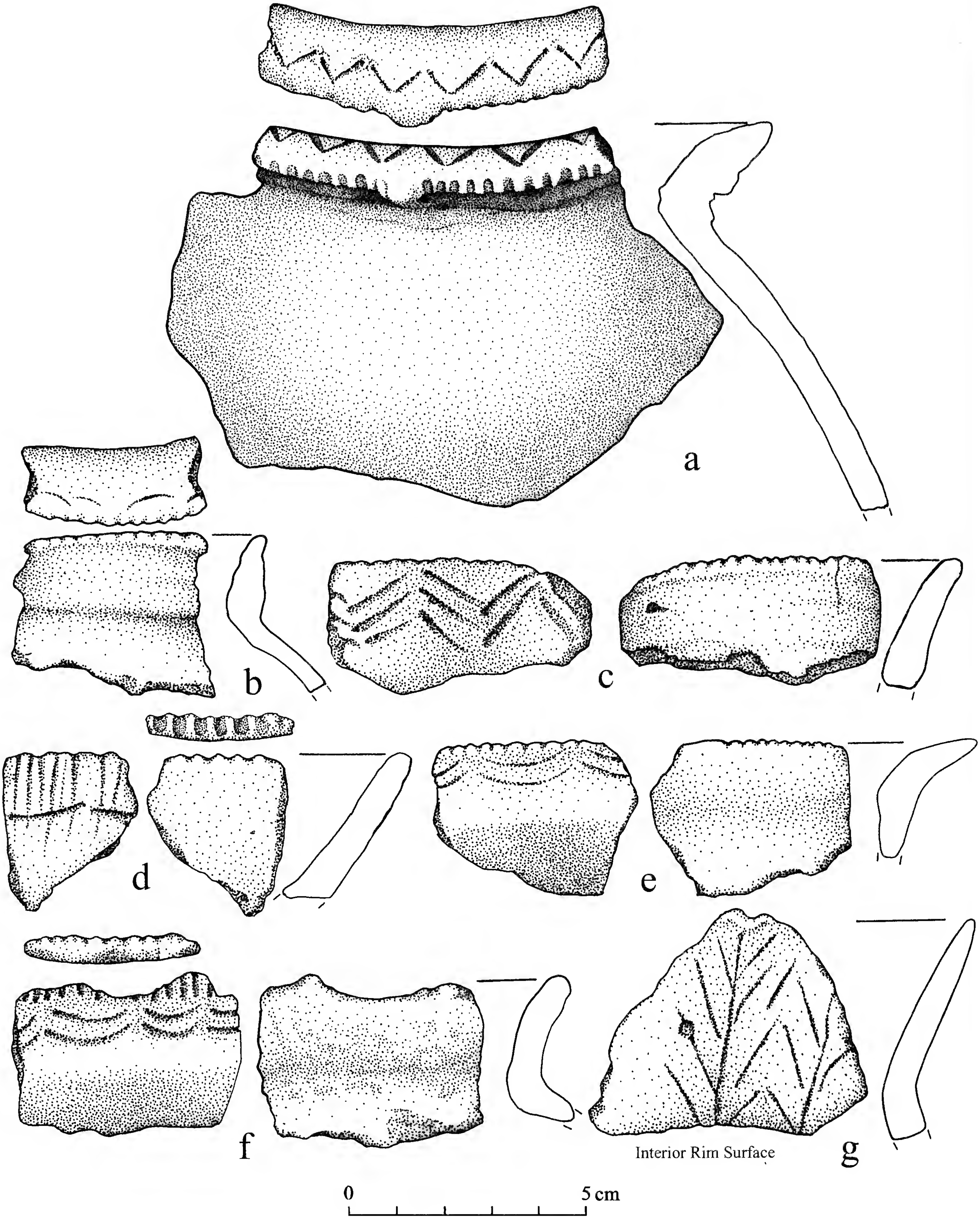

FIG. 5.8. Aiser, ABLP 615, Aitape.

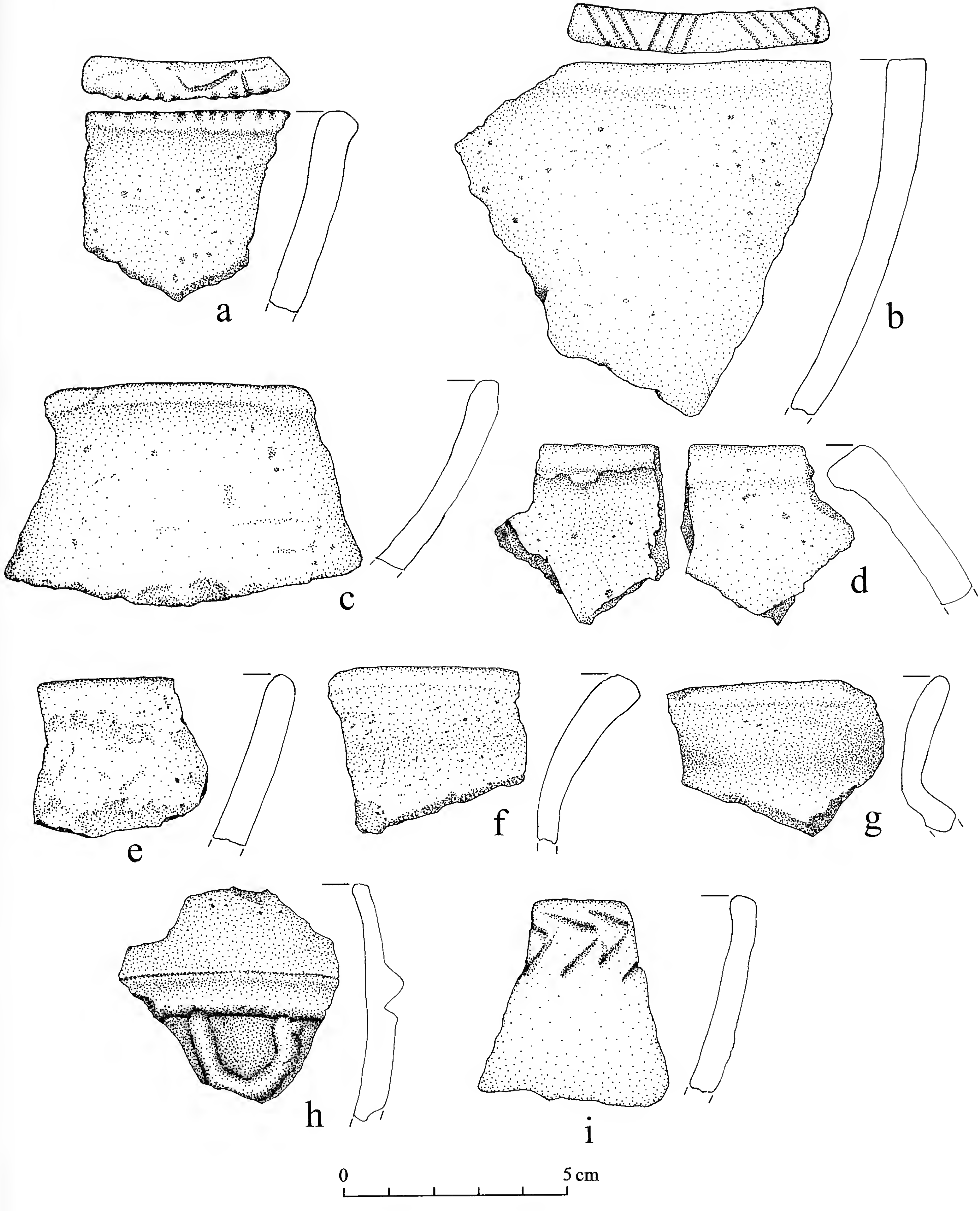

FIG. 5.9. Aiser, ABLP 615, Aitape.

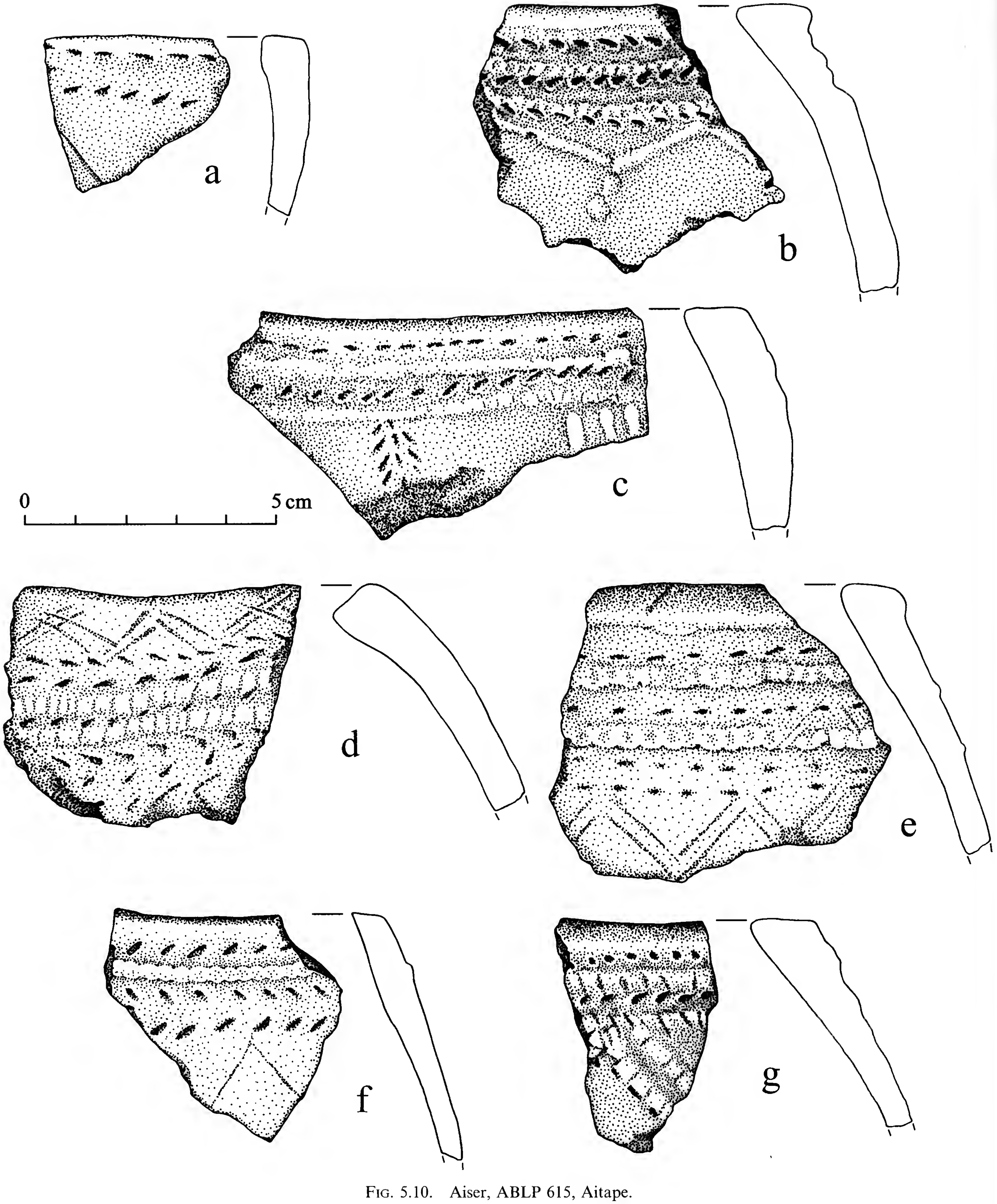

FIG. 5.10. Aiser, ABLP 615, Aitape.

characteristics that would later typify what we have called Wain Ware in the Aitape sequence (Chapter 7).

AITAPE—Highly irregular surface contours of an old upraised reef system form the steep ridges and low hills around the modern town of Aitape. In 1990 during our first trip to the Sepik coast, Welsch and I found small, weathered red-slipped sherds here on Kiap Point overlooking the sea on the west side of Aitape. In 1993, Welsch and two students from the University of Papua New Guinea recovered more than 500 similarly appearing sherds from the area of a road-metal quarry

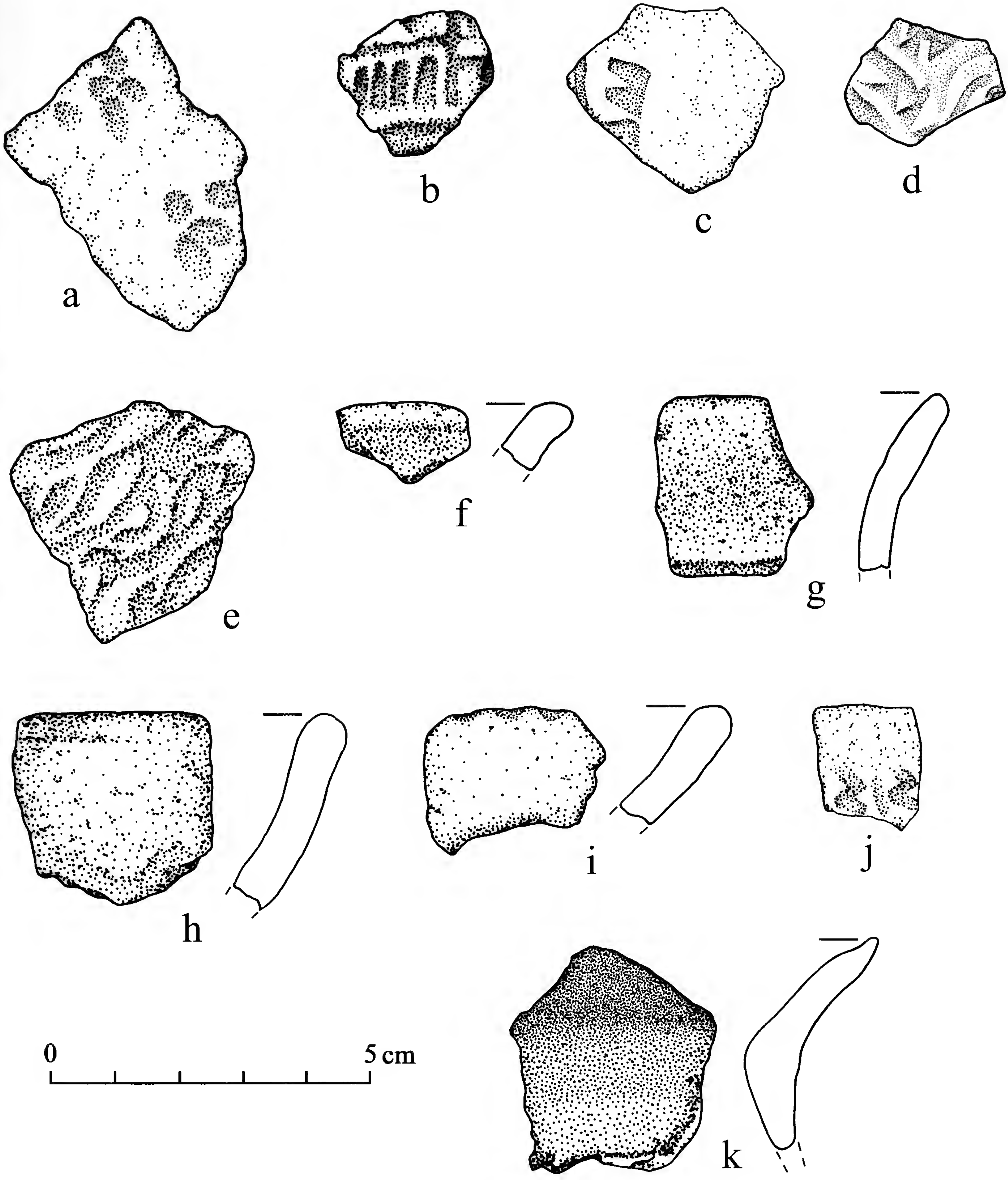

FIG. 5.11. Sumalo Hill, ABLP 649b, Aitape.

on the east side of town in a locality they were told is called Sumalo Hill (−3.151°, 142.369°). Because of the eroded state of most of the sherds, it was difficult to tell whether they had been red slipped, but unquestionably red-film slipping can be observed on some of them. Also in evidence were occasional surface impressions of uncertain form. Vessel forms included everted-rim pots and open bowls with simple (i.e., rounded) lips (Fig. 5.11). Among the everted rim sherds were ones with a distinctively "rolled," or outwardly curving, rim profile.

TUMLEO ISLAND—Tumleo (−3.122°, 142.397°; Fig. 5.12) is an oval uplifted low coral platform roughly 1.35 × 0.90 km in size with a small outcropping of the Bliri volcanics on the northwestern corner of the island (Haantjens, 1972, pp. 50, 57, 180, 230; Norvick & Hutchison, 1980, table 1) locally

FIG. 5.12. Tumleo Island seen from the beach at Aitape, 1990.

known as the "Little Mountain" that has long been a source of potter's clay (Chapters 8 and 13). In October 1896, the Society of the Divine Word established the Prefecture Apostolic of Wilhelmsland on Tumleo Island. Since then, Tumleo has been a major point of contact between the Sepik coast and the rest of the world. The surface collections obtained in 1993 were made at four principal localities on the island.

Ainamul (ABLP 177; −3.126°, 142.395°) is a modern house area on Ayar clan land at the southern end of the island. The materials obtained were a selection of sherds from cleared ground in an obvious dump area near the houses. Many of the sherds are quite thick and notably flat-lipped; they probably come from large sago storage pots, such as those still seen on Tumleo that are heirlooms from earlier in the 20th century. This locality also yielded bottle glass and pieces of glazed ceramic plates suggesting that the sherds obtained are of fairly recent age, although they are far thicker and have more strikingly flat-lipped rims than currently produced storage vessels. Bold incising is the decorative technique favored, and the motifs appear to be similarly bold derivatives of late prehistoric Wain motifs done using punctation, incising, and herringbone elements as well as short appliqué bands or nubbins (Figs. 5.13 and 5.14).

Wain (ABLP 178; −3.117°, 142.395°) is a named locality immediately back from the beach southwest of the Little Mountain at the northern end of Tumleo. The surface collection made here derives from both within and beside the trail running along the west side of island. Also recovered in addition to pottery sherds were nine pieces of chert of various colors and several other pieces of stone as well as one piece of clear bottle glass. While the number of decorated sherds was small, the pieces collected were distinctive enough to define the essentials of a pottery style we have called Wain Ware after this locality (Fig. 5.15). The traits considered to be diagnostic of this ware include herringbone punctation and incision, zoned herringbone motifs, appliqué bands, and small punctations done in a line just below the exterior lip edge, which is usually flat when the vessel wall was thick enough to be finished off in such a manner (Chapter 7). Also diagnostic (but see below) is the absence of red-clay surface slipping.

At Anilamo (ABLP 180–181; −3.117°, 142.397°), two scattered surface collections were made on the east side of the "Little Mountain" at the northern end of the island. In addition to one Wain Ware sherd with a row of fine dot punctations beneath the rim edge and then three rows of incised hanging arches below these, the sherds collected are thick (0.8–0.9 cm) and much like those recovered from Ainamul (ABLP 177, above).

At Nyapin (ABLP 179; −3.126°, 142.397°), the collection was made within the confines of the Mission Graveyard (Nyapin clan land)—which is located between Sapi Hamlet at the southern end of Tumleo and the Mission grounds immediate northeast of that hamlet—comes from a scatter of materials undoubtedly brought up from various subsurface depths during grave digging. Sherds in the styles we have called Aiser and Wain wares are numerous in the collection made here (Figs. 5.16 and 5.17).

Judging by their physical appearance (e.g., color, hardness, surface texture, and so on) as well as their unusual design

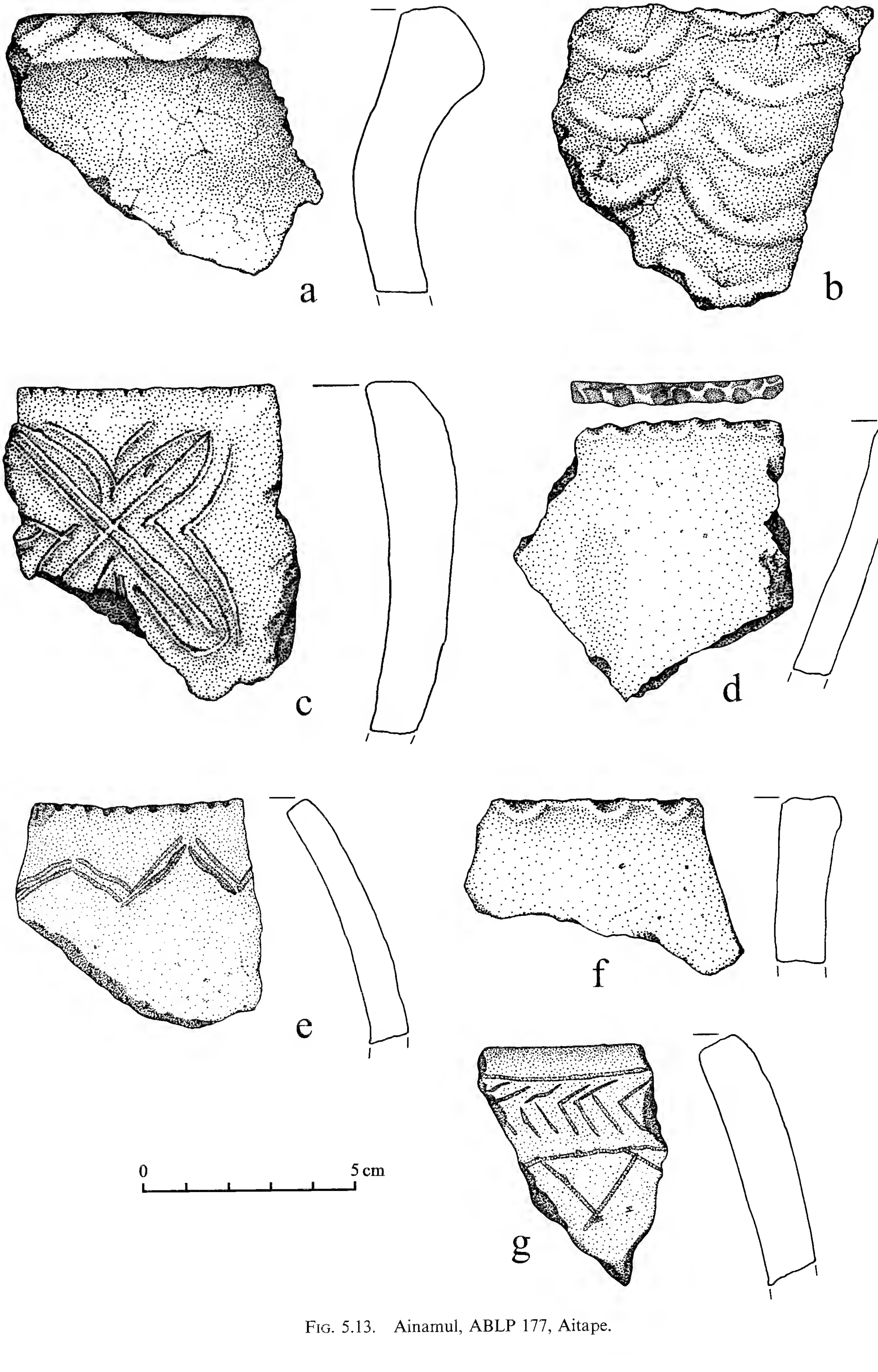

FIG. 5.13. Ainamul, ABLP 177, Aitape.

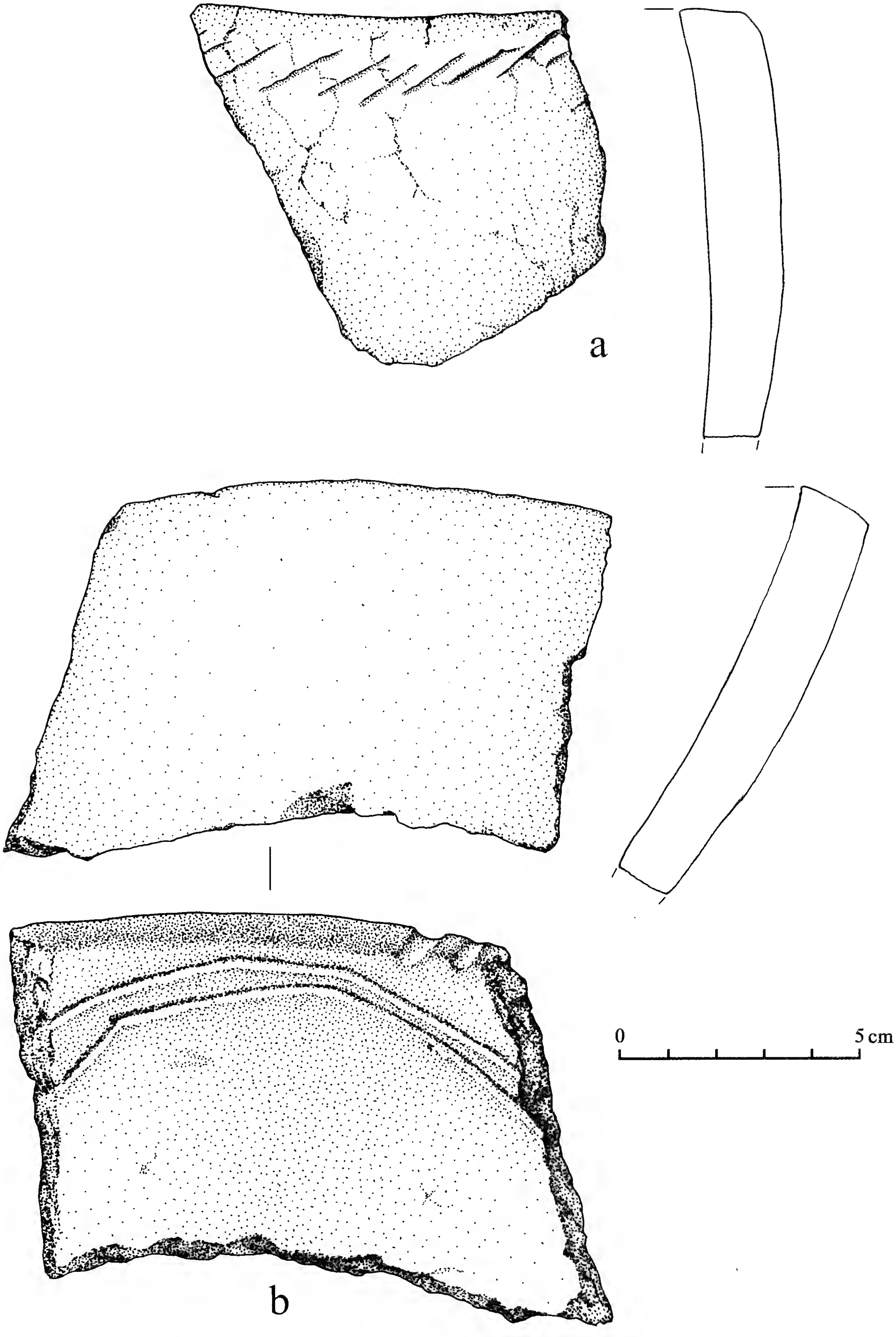

FIG. 5.14. Ainamul, ABLP 177, Aitape.

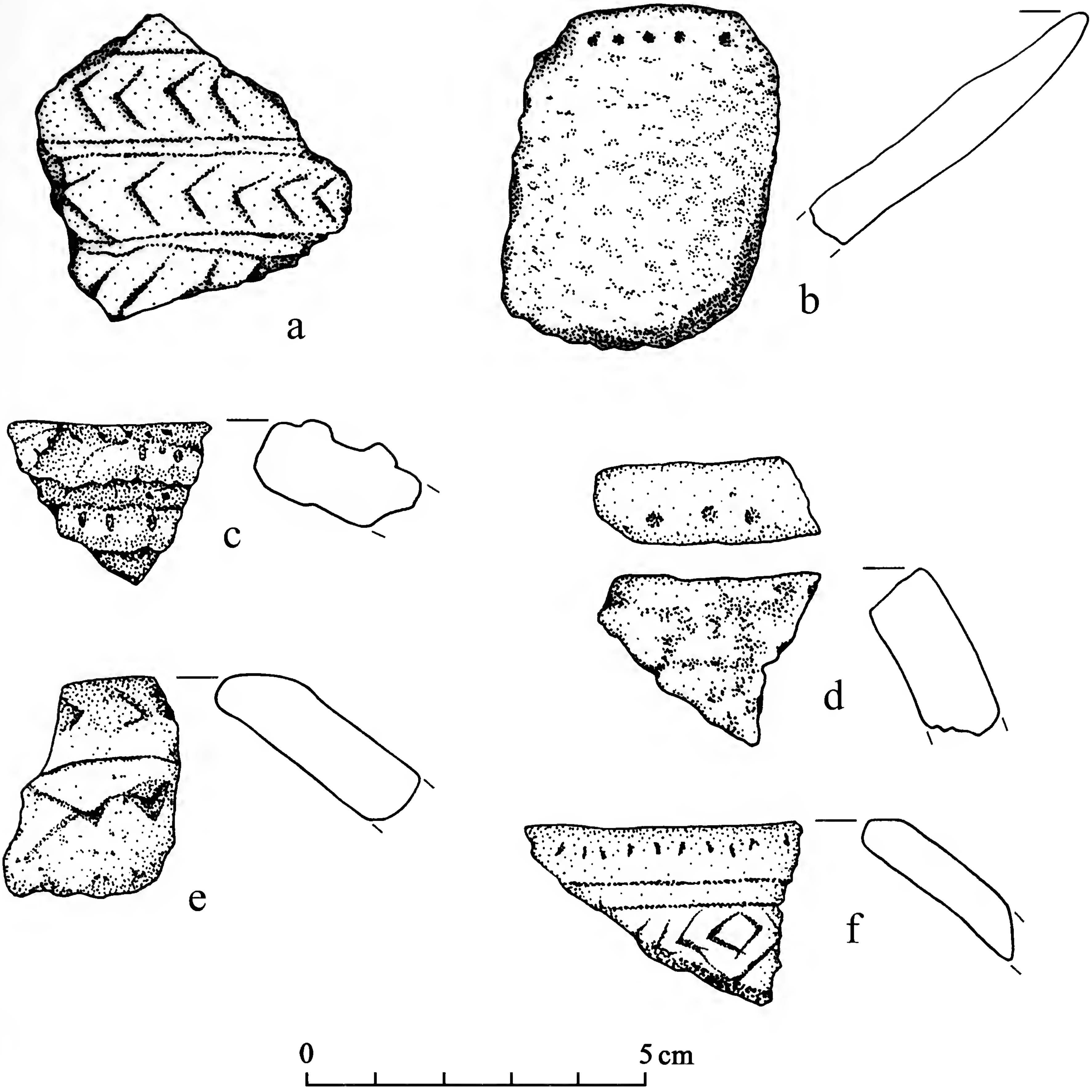

FIG. 5.15. Wain, ABLP 178, Aitape.

traits, three of the sherds found in the graveyard are evidently from pottery vessels imported from elsewhere, probably from the nearby mainland (compare Figs. 5.16g, i, and k with those from Old Ramu shown in Figure 5.7 as well as those from Rainuk Airfield in Fig. 5.3). Moreover, the sherd shown in Figure 5.16a, which is decorated with a motif now thought to symbolize the track of a sea turtle (Terrell & Schechter, 2007, fig. 26), is red slipped—a design trait typical of both Sumalo and Aiser wares rather than Wain Ware, which is almost invariably unslipped. Additionally, the pairing of linear rows of punctations and diagonal ("herringbone") incisions on this particular specimen mirrors the characteristic Aiser Ware attribute theme of combining herringbone incisions or punctations with punctate appliqué bands (e.g., Fig. 5.16l). By thus exhibiting design traits of both Aiser and Wain wares, this singular specimen substantiates the inference based on stratigraphic evidence that the latter developed stylistically out of the former (Chapter 7). For further discussion, see GENERAL OBSERVATIONS below.

CLAY SAMPLES—Rob Welsch was given clay samples (*paic*, "clay") from Ropina Ewa, a potter belonging to the Nyabau Clan at Sapi Village on Tumleo: ABLP 164: *paic trarun* obtained on the mainland at Raihu Camp and described by Ms. Ewa as "like flour"; ABLP 165: *paic nuwaic* obtained from the hill behind St. Mary's at Aitape near Kiap Point and referred to as "black clay"; ABLP 166: *paic pai* obtained on the mainland at Raihu Camp and described as "red clay"; and ABLP 167: *paic nuwaic* dug from a potter's pit on the side of Solyaliu (the "Little Mountain") called Saramatian owned by Koni and family at Ali Village on Tumleo. All these varieties

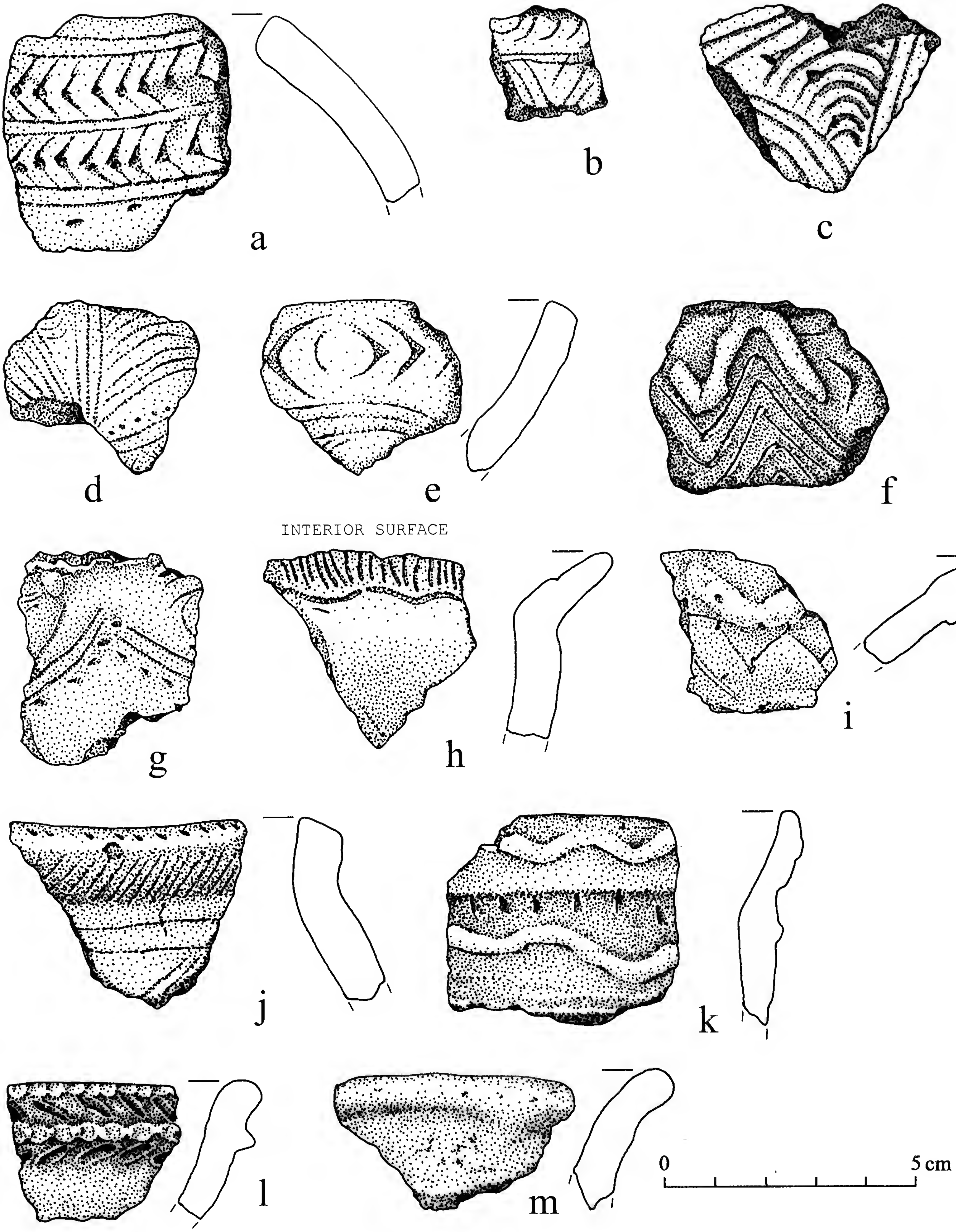

FIG. 5.16. Nyapin, ABLP 179, Aitape.

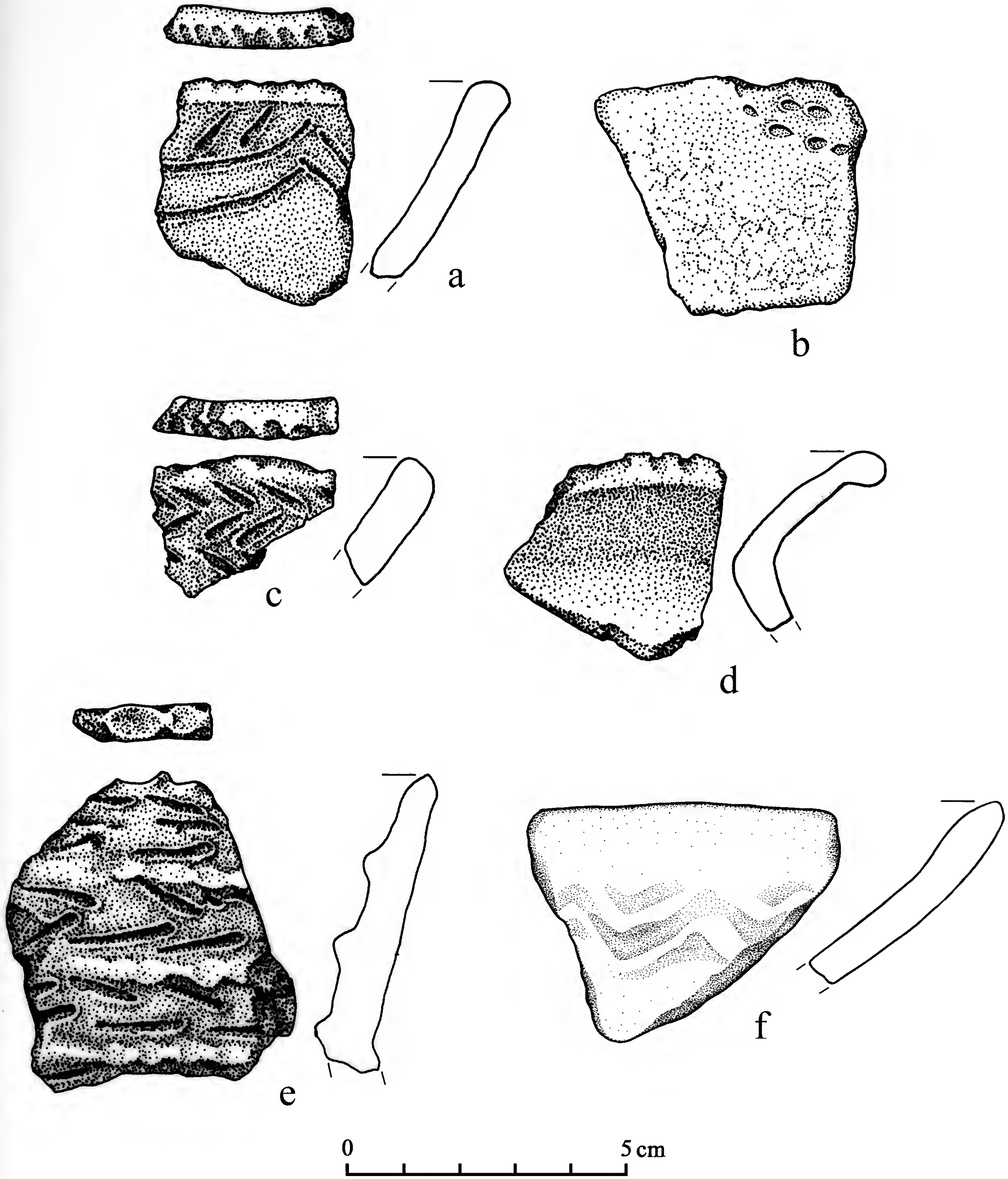

FIG. 5.17. Nyapin, ABLP 179.

of potter's clay can be obtained on Tumleo except for *paic pai*, red clay, which must be obtained from the mainland.

In 1990, Welsch and I learned at Yakoi Village (Sero Camp) on the mainland just west of Aitape that "red" clay locally called *nyakam* can be obtained at a hill named Kapalabar at No. 2 Pasis, a hamlet (approx. −3.1290°, 142.3477°) between Yakoi and Kiap Point on the western side of Aitape. A second variety of clay, called *trarun* at Yakoi, described as gray or black clay and said to be a lot like cement, can be obtained from a hill immediately behind Sero Camp. Finally, a third locally recognized variety of clay from a potter's pit in the side of the rise just behind Weyokapin Camp, Yakoi Village, described as "brown clay," is locally called *nuaic*.

Ali Island—The neighboring islands immediately east of Tumleo are low-lying uplifted coral platforms. None is said to have been a pottery-making place in the past, although all three are known for having made shell valuables of various sorts, including shell arm rings. Ali Island (−3.127°, 142.469°) is 1.55 km long and 0.65 km at its maximum width. While nearly 600 obsidian flakes were recovered from paths all across the central eastern side of the island, little in the way of decorated pottery was found on Ali, and most of what was recovered was nondiagnostic. However, a single decorated Lapita body sherd was picked up on the upraised terrace just behind the current beach front at Tubungbale (ABLP 641), and elsewhere on the eastern side of the island sherds in all the wares currently recognized in Aitape ceramic sequence, including Nyapin Ware (both fine-line scoring and wavy scoring; Chapter 7), were found.

Seleo Island—Seleo (−3.146°, 142.487°), a small rectangular island 1.0 × 0.75 km in size, was intensely bombed during World War II and was also extensively bulldozed for an airfield built then, too. Like neighboring Ali Island immediately to the northwest, there is an obvious terrace slightly inland from the present beachfront that may be a sign of local tectonic uplift rather than a previous sea-level highstand.

ABLP 139 is a series of five surface collections begun 92 paces from the rear of Seleo Village (at approx. −3.146°, 142.485°) and running inland for somewhat more than 60 paces. These collections were labeled as Area A-1 (9 × 8 paces), Area A-2 (20 × 7 paces), Area A-3 (10 × 6 paces), Area A-4 (14 × 9 paces), and "farther back" (this latter is a selective collection of materials picked up while walking away from Area A-4 toward the village church [−3.149°, 142.487°] on the southern side of island). While there were few decorated sherds in any of the collections made, what was found indicates use of the island when Aiser and Wain wares were popular (as witnessed by sherds with punctate appliqué bands and red film in the former instance, and zoned herringbone punctations and plain appliqué bands in the latter), that is, at least for the past 1,000 years or so.

ABLP 160 is a surface collection made from the cleared ground around the village church and along the path to the south leading toward the shore. The decorated sherds recovered are mostly nondiagnostic, but red surface filming (red clay slip) is well attested, as is the decorative use of punctate appliqué bands commonly associated with Aiser Ware.

Angel Island—Angel (−3.127°, 142.469°) is the smallest of the four islands off the Aitape coast today, with its main islet only about 0.18 km at its widest point. It is reportedly undergoing slow but perceptible uplift. ABLP 604 is a surface collection ("Collection Area #2") from a low midden rise approximately 20 paces back from the coral edge of the islet on its northern side facing Seleo Island. The island's cemetery is immediately adjacent on the west side of the midden; an *anopareak* (men's house) is said to have once stood between this midden rise and the sea on its east side. A charred stump said to be one of the posts of this structure was still visible in 1993. The area is called Chalsing ("Place No Good") and belongs to the Anochareng clan. The collection made includes sherds from everted as well as inverted rim vessels and sherds having one or more of these attributes: red film (clay slip), appliqué band, punctation, and incised linear or curvilinear design elements, including herringbone punctations—suggesting use, if not necessarily permanent occupation, of this small islet dating back to when Aiser Ware and then later Wain Ware were locally available. Also found were two unifacially cored shell-ring cores as well as a fragment of a ribbed ceramic (European) arm ring.

Table 5.3. Proposed spatial seriation of the surface collections made in the Aitape area.

Proposed chronology	Collection
Modern and historic Tumleo pottery	A. B. Lewis
Wain pottery	ABLP 178 and 179
Aiser pottery	ABLP 615 and 616
Sumalo pottery	ABLP 649

ABLP 605 ("Collection Area #1") is from a low-midden rise next to the beach facing Seleo Island on the northeast side of Angel Island. On land belonging to the Sokolal clan, like ABLP 604 it is reportedly the site of a former men's house. The decorated sherds in the collection chiefly have incised or wavy-band appliqué design attributes, although there is a single Wain zoned herringbone punctate sherd. The assemblage taken as a whole suggests that most of the material recovered comes from a late Wain occupation similar to, although perhaps earlier than, that at Ainamul (ABLP 177) on Tumleo Island. Also present in the collection, in addition to pieces of rusted sheet metal presumably from World War II, are a single chert flake and three unifacially cored shell-ring cores.

General Observations—All the material collected during our survey work in 1993 was given preliminary study while I was still in New Guinea. Although impossible to confirm without benefit of stratigraphic excavation, I was able to hypothesize in 1993, based on both stylistic characteristics and spatial segregation, that the ceramic finds from Sumalo (ABLP 649), Aiser (ABLP 615–616), and Wain (ABLP 178, as well as many of those in the collection from ABLP 179) make up a probable ceramic sequence culminating in historic and modern Tumleo Ware (Table 5.3; Chapter 8). However, some of the design characteristics seemingly typical of Wain ceramics (Fig. 5.21e) resemble arguably older design traits found at Sareta and Simindibubu on Tandanye (Fig. 5.21). Therefore, it was also clear in 1993 that excavated stratigraphic evidence would be needed to confirm and determine the antiquity of the stylistic transformations suggested by this provisional sequence. There was no hint in 1993 that what we now refer to as Nyapin Ware (Chapter 7) would be found in one of the test pit excavations on Tumleo Island in 1996.

Tandanye-Walis Area

Suain—ABLP 199 is a small sherd collection from here and there in the present beachfront hamlet of Lelap at Suain (−3.350°, 142.916°).

Karesau Island—Karesau (−3.391°, 143.449°) is a small elongated coral island 2.75 km long and 0.35 km wide at its widest point located just off the Boiken coast west of Kairiru and Muschu islands and the coastal town of Wewak. Soil development on Karesau is shallow enough that garden planting is done in small pockets hollowed out of the coral

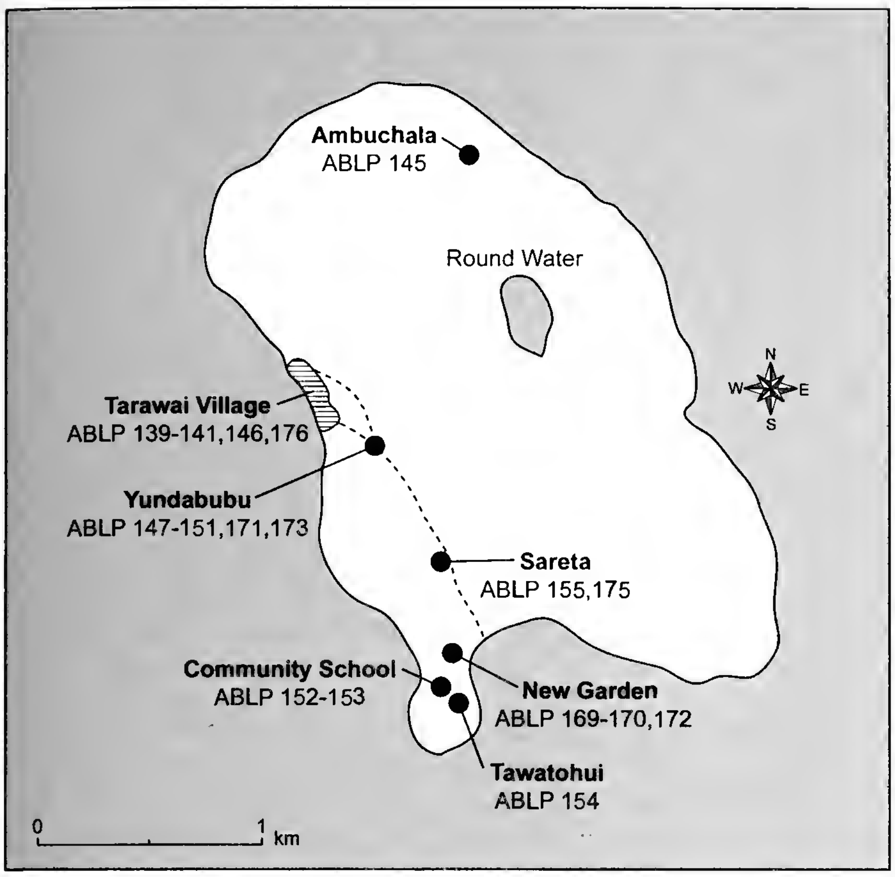

FIG. 5.18. Tandanye (Tarawai) Island showing archaeological locations discussed in the text.

bedrock that are then filled with sifted and slightly mounded soil. The coral excavated from these pockets is discarded along the sides of the garden areas, creating low bordering garden ridges unlike anywhere else seen on the coast or offshore islands.

ABLP 195 is a general surface collection of finds picked up here and there over approximately the eastern one-third of the island. Design attributes attested include incision, appliqué band, punctate appliqué band, and crosshatch incising. More specific description or attribution is not possible at this time because of the small size of the collection. ABLP 196 is a similarly small and rather nondescript collection that includes a few potsherds, 36 small obsidian flakes, and a small fragment of a small adze of a greenish stone. ABLP 197 is a single unifacially cored shell-ring core picked up from the ground at Wutwulin Hamlet on the island. ABLP 198 is a more substantial but nonetheless seemingly nondiagnostic collection of potsherds from a midden at Tera Hamlet on the southern shore of the island. Design attributes evidenced include incision, appliqué band, punctate appliqué band, and everted rim vessels.

TANDANYE ISLAND—Tandanye (also know as Tarawai) is an island roughly oval in shape of upraised coral with maximal dimensions of 2.98 × 1.9 km; there is a small peninsula on its southwestern side (Fig. 5.18). Like nearby Walifu Island to the east, Tandanye is big enough to have a small freshwater lake that makes it possible to grow a limited amount of sago on the island, although sago is also imported from Walis and the mainland.

On 9 September 2002, an earthquake with a surface-wave magnitude of 7.8—one of the strongest earthquakes ever recorded for northwestern Papua New Guinea—caused serious structural damage to houses and water tanks, triggered landslides, and uplifted the ground surface of the offshore islands of Tarawai, Walis, Kerasau, Kairiru, and Muschu as much as 30–40 cm, leading to the emergence, at midtide, of reefs and wave-cut platforms and the setting of new strand lines on the beaches. A moderate tsunami, having a maximum amplitude of 3–4 m, was generated at the same time as or soon after the earthquake (Ruddick, 2005).

FIG. 5.19. Shell ring manufacture, Tandanye (Tarawai) Island, 1993.

Tandanye's surprisingly convoluted landscape hints clearly that this tectonic event was not the first of its kind in the history of this island.

One of the main thoroughfares on Tandanye is a narrow and generally straight dirt road cut connecting the main village, which is located on the west coast, with the peninsula and small harbor at the southern end of the island (Fig. 5.18). In spite of the obvious care with which this roadway is maintained, we were able to recover hundreds of small obsidian flakes from the well-trodden surface. It is probable that these flakes have washed into the road cut from the higher ground on either side. Locally these flakes are called *ombo niangkase*, "bush bottle glass." People on the island were surprised to learn from us that this glass had been imported in prehistoric times to Tandanye from sources well to the east.

Some of the obsidian flakes recovered from garden sites rather than from this main roadway are sizable chunks of volcanic glass. For example, one piece of obsidian we were given by Richard Tenka that he had found in his garden at a locality called Simirai is 5.7 cm wide and 6.0 cm long. It is still partially covered with cortex. Another from the same locality is 8.0 cm long. Both may be taken to suggest that obsidian

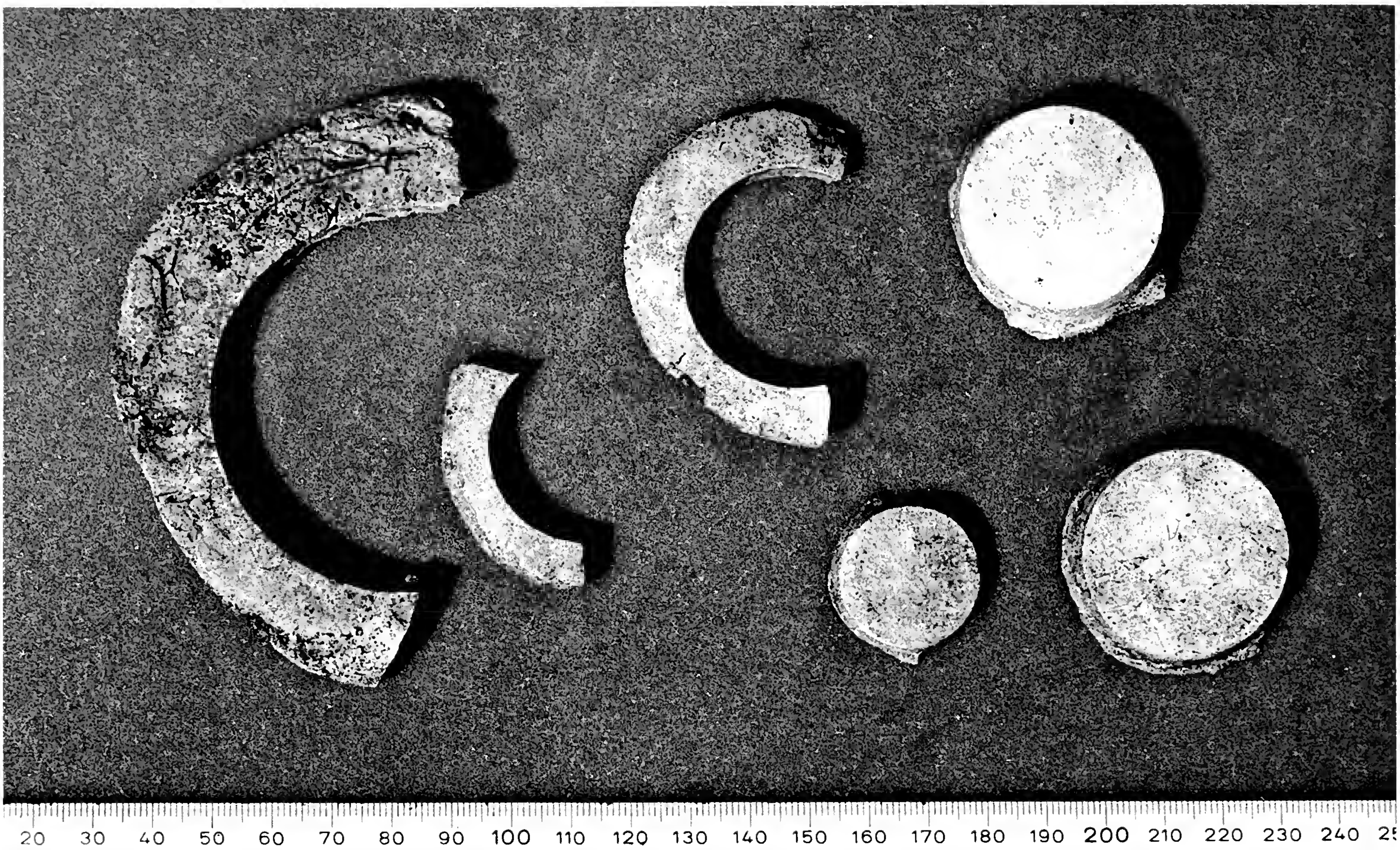

FIG. 5.20. Shell cores and ring fragments from Muchika Community School, ABLP 153, Tandanye-Walis.

reached this island in sizable blocks and was then locally worked and probably reused more than once if the small flakes that dominate the collections we made are an accurate indication of how obsidian ultimately fared on the island. Additionally, while one or more of the edges of many of the flakes of all sizes show evidence of possible use wear, only one of the flakes recovered appears to have been shaped into a clearly identifiable type of tool, such as a burin or a spear point. It thus seems that flakes were considered serviceable tools in their own right for whatever purposes they were used for.

Most of our survey time was spent exploring the area between the modern village and the peninsula. We were taken, however, to visit a traditional village site at a locality locally called Ambachala (ABLP 145) inland at the northern end of the island (Fig. 5.18; −3.196°, 143.257°). The site was mostly rugged coral with garden pockets of earth here and there. Only four sherds were recovered, one of which was crosshatch incised.

Like the roadway running down to the southwestern peninsula, the modern village area, which comprises at least nine named hamlets, is well maintained as cleared ground. Little, therefore, was recovered there. Judging by their appearance, most of the decorated sherds found are probably from the pottery-making communities at Kep and Terebu villages on the mainland. One sherd from Sma Hamlet (ABLP 146) on Tandanye has a herringbone-incised motif making it identifiable as derived from a Wain Ware pot presumably from the Aitape area to the west.

Tandanye is known locally as a production center for shell rings, which were still occasionally being made there when we were visiting in 1993 (Fig. 5.19). Several broken rings as well as unifacially cored ring cores were recovered from the grounds around the community school on the southwestern peninsula (ABLP 152 and 153; Fig. 5.20) in surface association with pottery sherds probably from Kep-Terebu (e.g., Fig. 5.22a–e) as well as others from the Aitape area (both Aiser and Wain wares; e.g., Figs. 5.21e and 5.22g).

It is obvious that the uplift that occurred during the earthquake of 9 September 2002 was not the first time such an event has happened locally. The collection made in garden land at the locality called Sareta (ABLP 155) to one side of the main north–south road was picked up from the erosion slope and the first 8 or so meters at the top of a prominent rise estimated to be about 2.5–3.0 m above the current road surface. The sherds recovered from Sareta include ones from vessels with distinctive triangular lips and body sherds with incised and shell-edge impressions. The material found was quite fragmentary, so reconstructions are difficult to propose.

Among the sherds were several with red slip still in evidence, several from a carinated (shouldered) vessel with fine vertical incisions ending in small punctations tangential to the carination, and a zoned incised and shell-edge impressed sherd (Fig. 5.21f). Considered along with finds from garden areas at a nearby locality called Simindibubu (ABLP 171; Fig. 5.21a–d), this material resembles Nyapin Ware in the Aitape area in some respects (Chapter 7), and may be of similar age and stylistic derivation. Simindibubu, however, also produced sherds from vessels having triangular expanded lips somewhat reminiscent to those from New Garden, Area A (ABLP 169), although not as ornately modified and decorated as those from that locality (discussed immediately below).

A small, now uplifted former embayment on the southern peninsula of Tandanye had been newly cleared for garden use

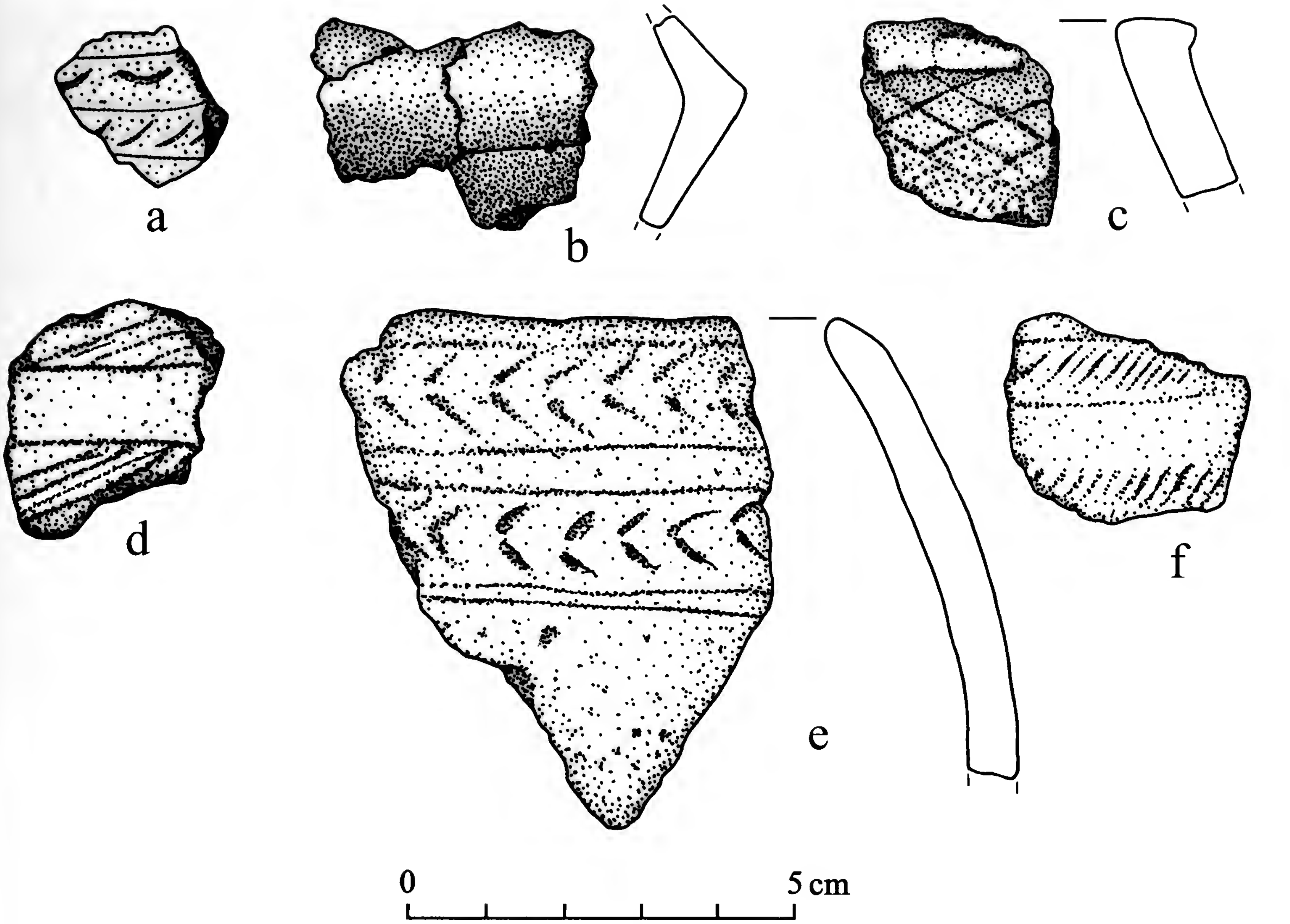

FIG. 5.21. Tandanye-Walis area. (**a–d**) Simindibubu, ABLP 171; (**e**) Muchika Community School, ABLP 152, a Wain-style sherd chemically sourced as probably coming from the Aitape ceramic tradition (sherd TW1521, Aitape-Barida 1, Appendix 13.3); (**f**) Sareta, ABLP 155.

when we surveyed the locality in 1993. The ceramic finds from the northern side of the basin-shaped area (New Garden, Area A, ABLP 169; Fig. 5.23) are different mostly in appearance from the finds recovered from the southern side of the same basin (New Garden, Area B, ABLP 170). Many of the pots on the northern side had large, heavy expanded lips (Fig. 5.23) reminiscent of what has been called "Type X" ware in the Huon Gulf region of northeastern New Guinea (Lilley & Specht, 2007). Associated with these finds were two sherds readily identifiable as coming from Aiser Ware vessels (Fig. 5.23q–r; see also Chapter 13). While the evidence is hardly conclusive, the recent redating of Type X Ware by Lilley and Specht (2007) to ~1,000–500 BP is compatible with the estimated age of Aiser Ware at Aitape (Chapters 7 and 14).

The finds from the southern side of the garden area are more difficult to characterize but include sherds with crosshatch incising, wavy-band appliqué, appliqué nubbins, broad wavy scoring, scoring with a double-pronged tool, and punctate appliqué band. It seems likely that the two areas are not contemporary and that Area B may be somewhat later in age, although the evidence is far too inconclusive to be definitive.

WALIFU ISLAND—Tandanye's immediate neighbor to the east, Walifu or Walis Island (−3.227°, 143.298°) is a roughly lenticular island with maximal dimensions of 6.40 × 2.25 km. There is a freshwater lake at its northwestern end that facilitates some sago to be grown on the island. ABLP 161 is a surface collection from newly cleared garden land 30 × 50 paces in area running up a slope of about 30°–40° just east of Walis Village on the southeastern side of the island. This collecting locality was said to be the location of a former village called Bwarni; the collecting locality itself is named Buamunding. Both time and heavy ground vegetation beyond the cleared garden area kept us from discovering the full extent of the surface evidence. The ceramic finds from this locality are for the most part strikingly different in their decorative treatment from anything collected elsewhere in 1993–1994 on the Sepik coast (Fig. 5.24). Decisive, often fairly deep, and sometimes quite large punctation is the technique favored on 35 rim and body sherds; double-pronged tools were used for both punctation and incision (e.g., Fig. 5.24d, g–i; compare May & Tuckson 1982, p. 100, figs. 5.31, 5.33–5.35, 5.49). Some of the sherds have join fractures and possibly "coil fractures" as well, hinting perhaps also of similarly distinctive construction techniques. The uniqueness of this material has been confirmed by laser ablation inductively coupled plasma mass spectrometry assays (Chapter 13). Our working hypothesis is that this material probably comes from a production source located to the east somewhere between Wewak and Madang.

Other decorative techniques present at ABLP 161 include punctation combined with incising, linear and crosshatch incision, and appliqué bands and punctate appliqué bands. Five of the crosshatch incised sherds found are from vessels

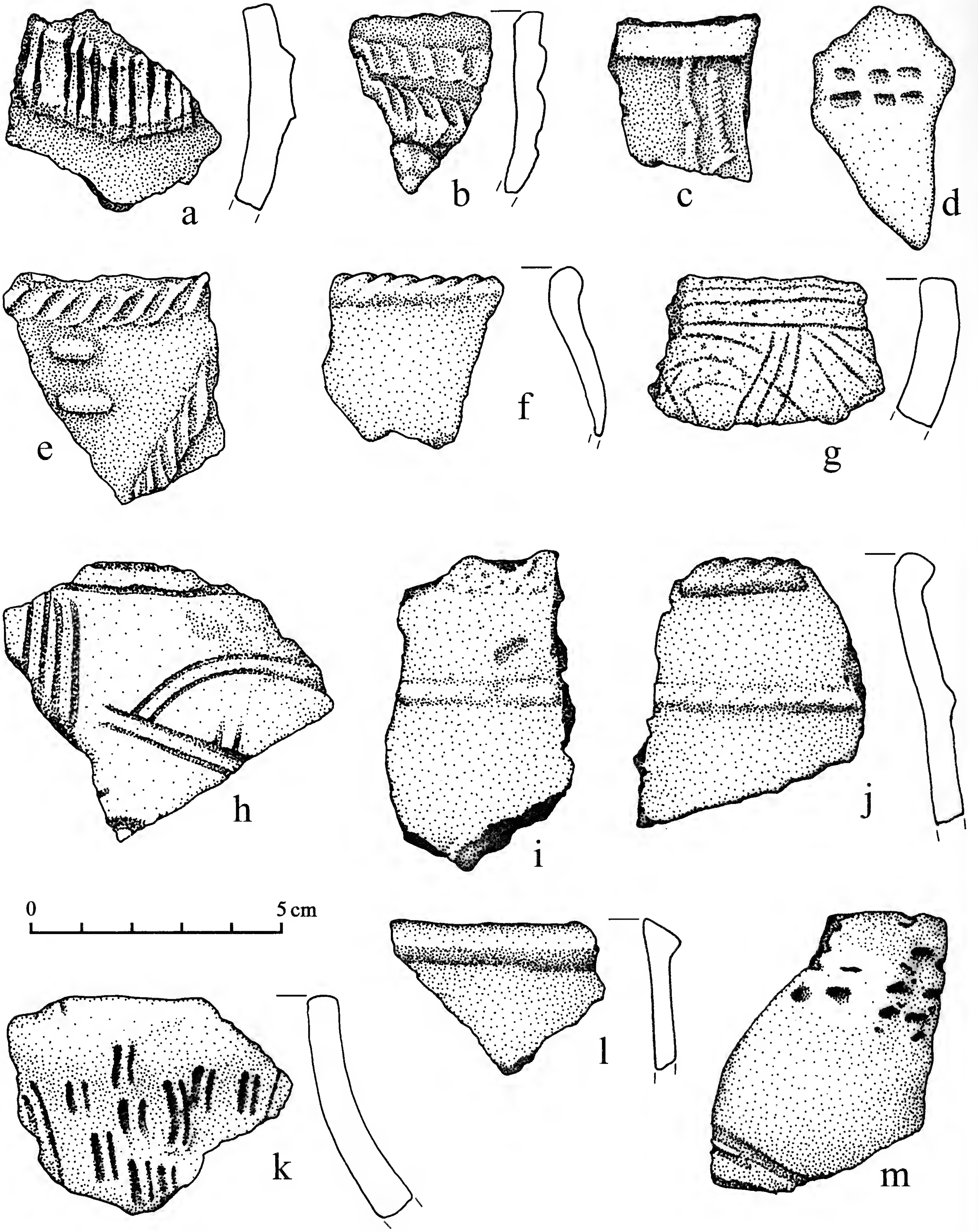

FIG. 5.22. Muchika Community School, ABLP 153, Tandanye-Walis; **g** is a Wain-style sherd chemically sourced as probably coming from the Aitape ceramic tradition (sherd TW1538, Aitape-Barida 1, Appendix 13.3).

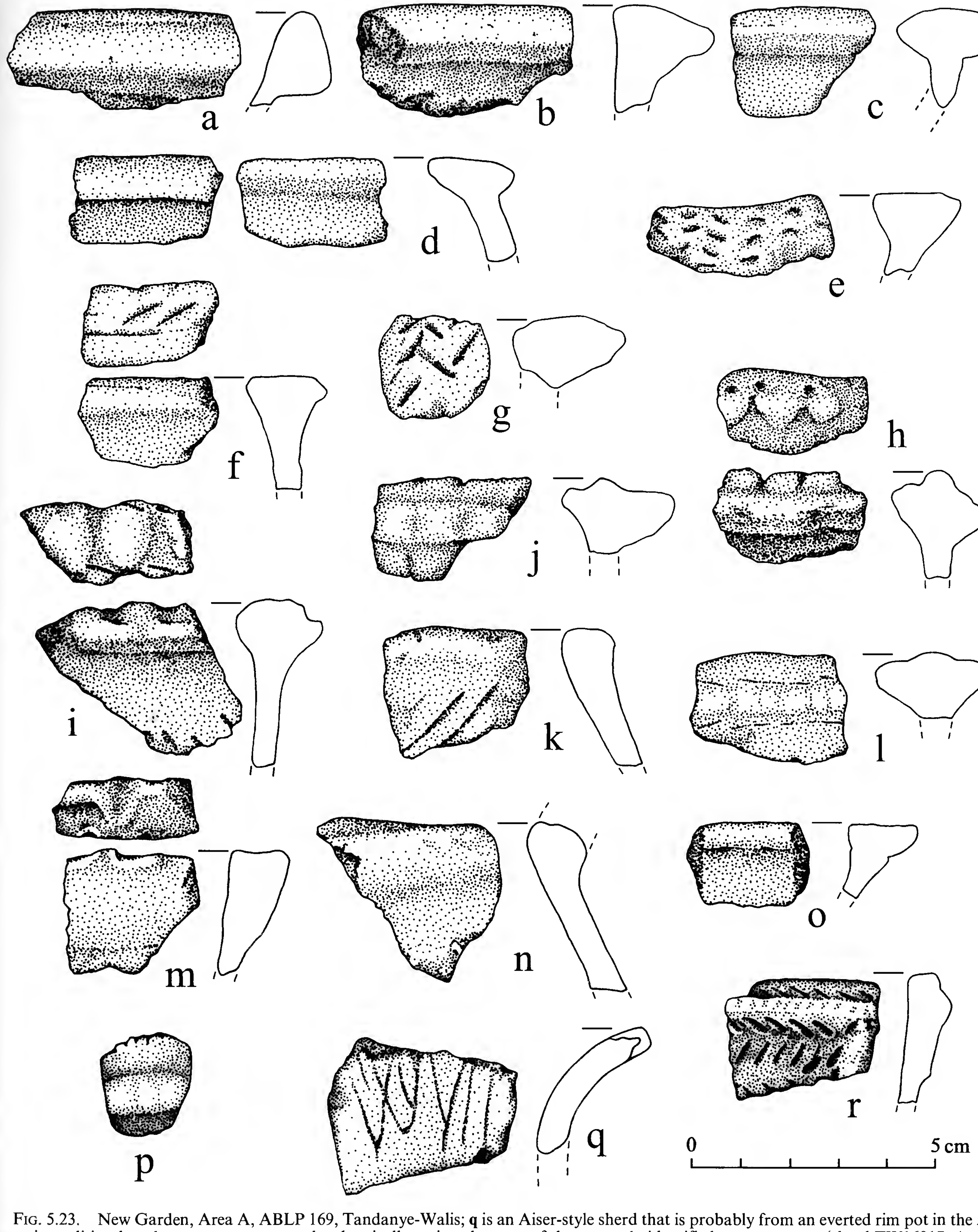

FIG. 5.23. New Garden, Area A, ABLP 169, Tandanye-Walis; **q** is an Aiser-style sherd that is probably from an everted rim pot in the Aitape ceramic tradition but that cannot at present be chemically assigned to one of the currently identified source groups (sherd TW16917, Appendix 13.3); **r** is an Aiser-style sherd chemically sourced as probably coming from the Aitape ceramic tradition (sherd TW16918, Aitape-Barida 2, Appendix 13.3).

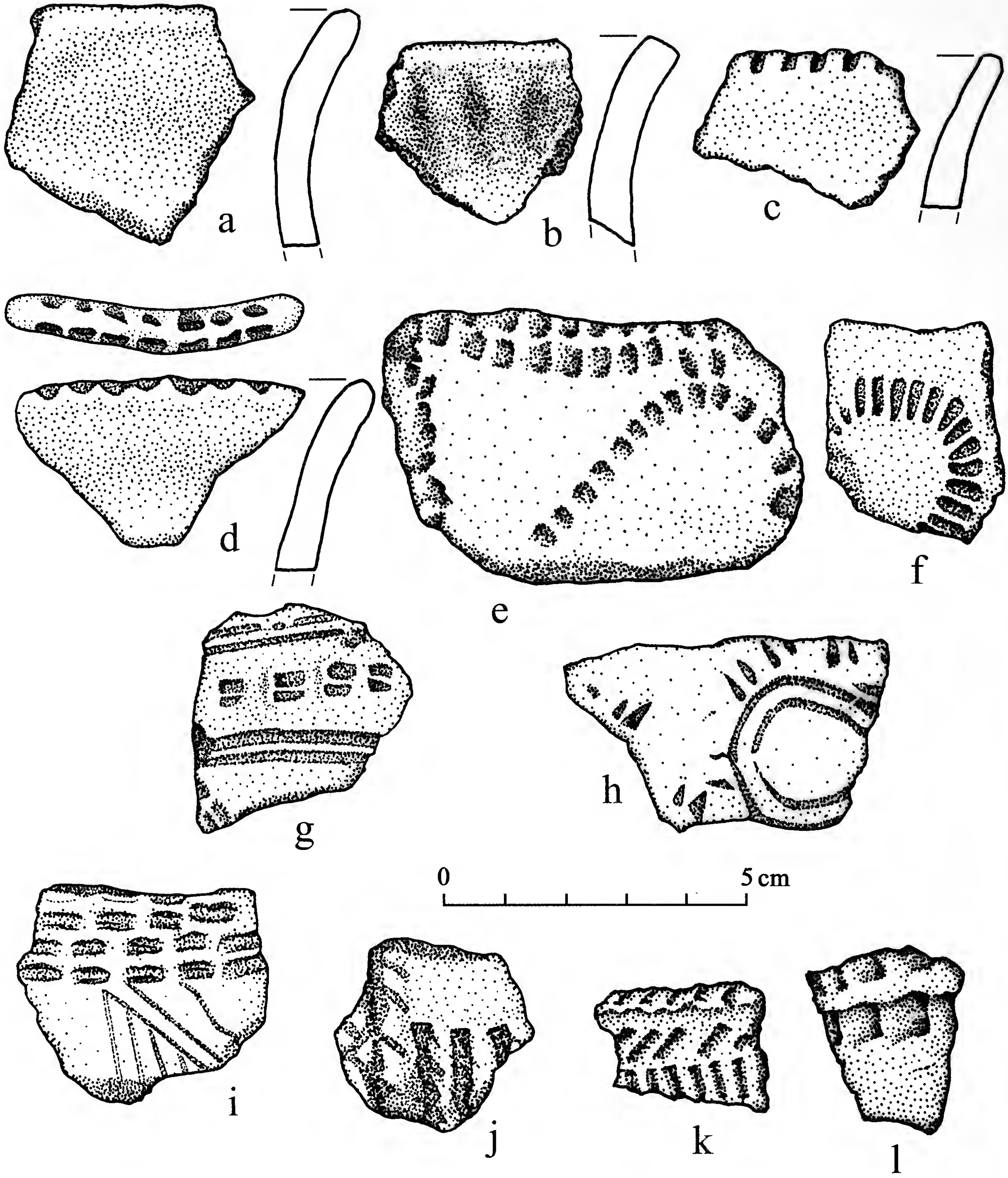

FIG. 5.24. Buamunding, ABLP 161, Tandanye-Walis.

having inverted rims and simple (unnotched) lips and are comparable to sherds collected at Lakeba (immediately below).

Lakeba (ABLP 162) is a collecting locality about 60 paces in length at the edge of the limestone cliff east of Walis Village; the area is a clearing around the stone and concrete base of a statue of the Virgin Mary. Most of the sherds were recovered from the cliff face, although small scattered sherds and flakes of obsidian were also picked up from the clearing itself. At the time of our visit, the statue had not been positioned on its base. It is not known if this was later done. It seems likely that the sherds from the cliff face were thrown there while the ground was being prepared for this purpose.

The sherds picked up at this locality are strikingly homogeneous. They are thin (0.3–0.4 cm to a maximum of ~0.7 cm), and the main decorative technique used is fine-line and linear crosshatch incising (Fig. 5.25). Vessels generally have everted lips and are usually notched. Present but less

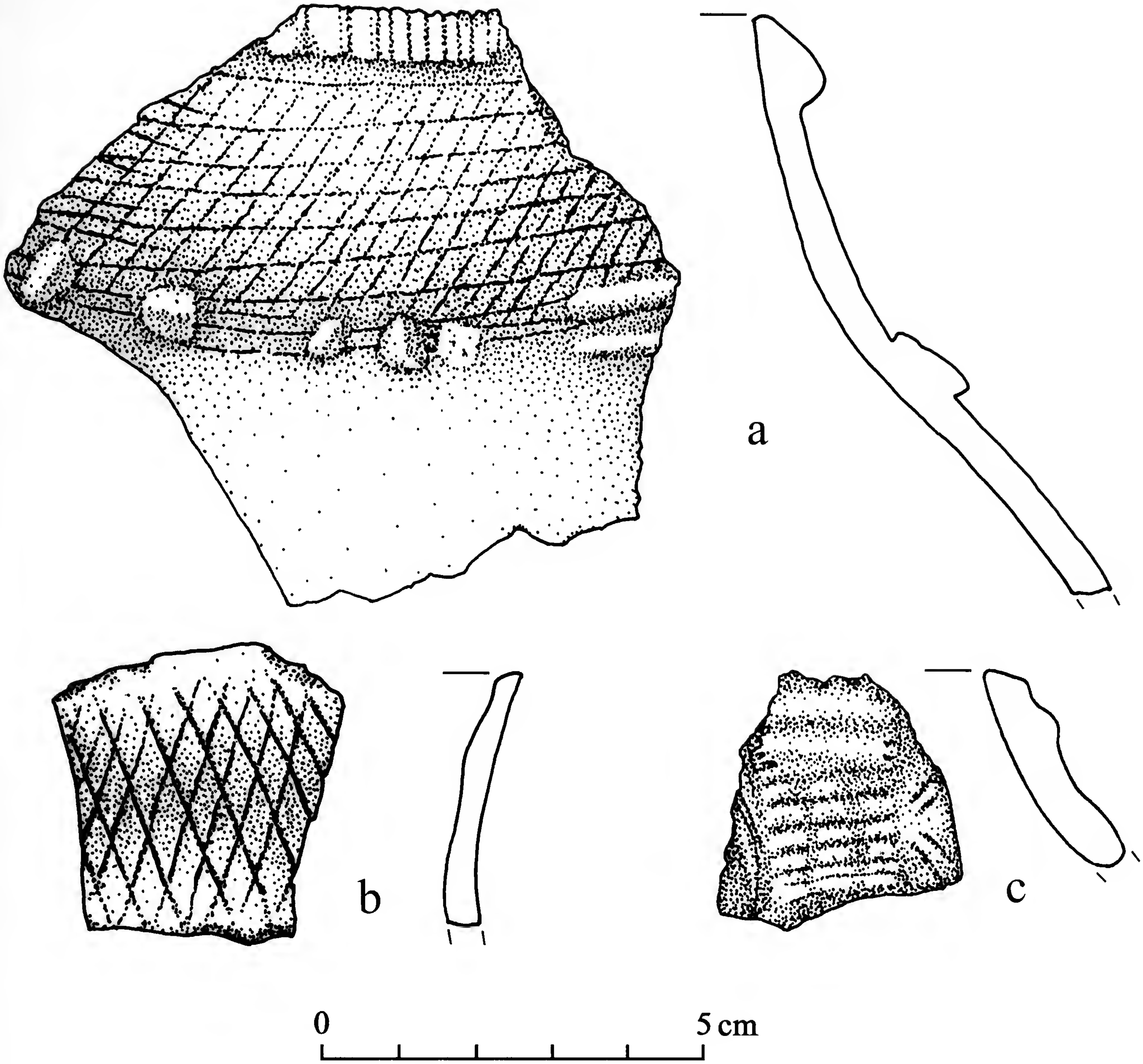

FIG. 5.25. Lakeba, ABLP 162, Tandanye-Walis.

common are appliqué nubbins, appliqué bands, and rare punctate appliqué bands. Fifteen of the decorated sherds evidence the use of a double-pronged tool for both punctation and incising.

The collections labeled ABLP 663a–c are all surface finds from the bare ground in and around Kambilal Hamlet (−3.243°, 143.304°) at the extreme south tip of Walifu Island. ABLP 663a is from a surface scatter of sherds from the hamlet's graveyard on its southwestern side; none of the specimens is decorated sufficiently to be stylistically distinctive. ABLP 663b is a much larger collection of sherds and obsidian flakes from the ridge that runs down to the village. Also found were two lumps of yellow ochre. Decorative attributes attested include appliqué bands, punctate appliqué bands, crosshatch incising, and double-prong punctation and wavy scoring. Rims include rolling everted rims resembling those still made at Kep-Terebu on the mainland. On stylistic grounds, it seems likely that much of the collection may come from there, and if so, may be of recent origin. ABLP 663c is a collection put together by schoolchildren while we were there gathered from within the hamlet area on land associated with the Nyumindom clan. In addition to eight small obsidian flakes, the small pottery collection includes a few sherds documenting the occurrence of crosshatch incising and punctate appliqué bands but that otherwise are too eroded to be classified.

MUSCHU ISLAND—A somewhat rugged and irregular-shaped island approximately 10.3 × 6.5 km in its maximal dimensions. ABLP 183 is a collection from a surface area of about 8 × 30 paces on a low elongated rise (−3.421°, 143.628°) paralleling the pathway to the church at Sup on the eastern end, or peninsula, of the island. Decorative attributes in evidence include appliqué band, punctate appliqué band, appliqué bobbins, and both linear and crosshatch incising; judging by appearance, the probable sources for the ceramics are pottery-making communities at Kep and nearby Terebu on the mainland east of Wewak. ABLP 184 is a surface collection from a low rise about 45 paces from the beachfront at the back of the modern village of Sup No. 2. Decorative

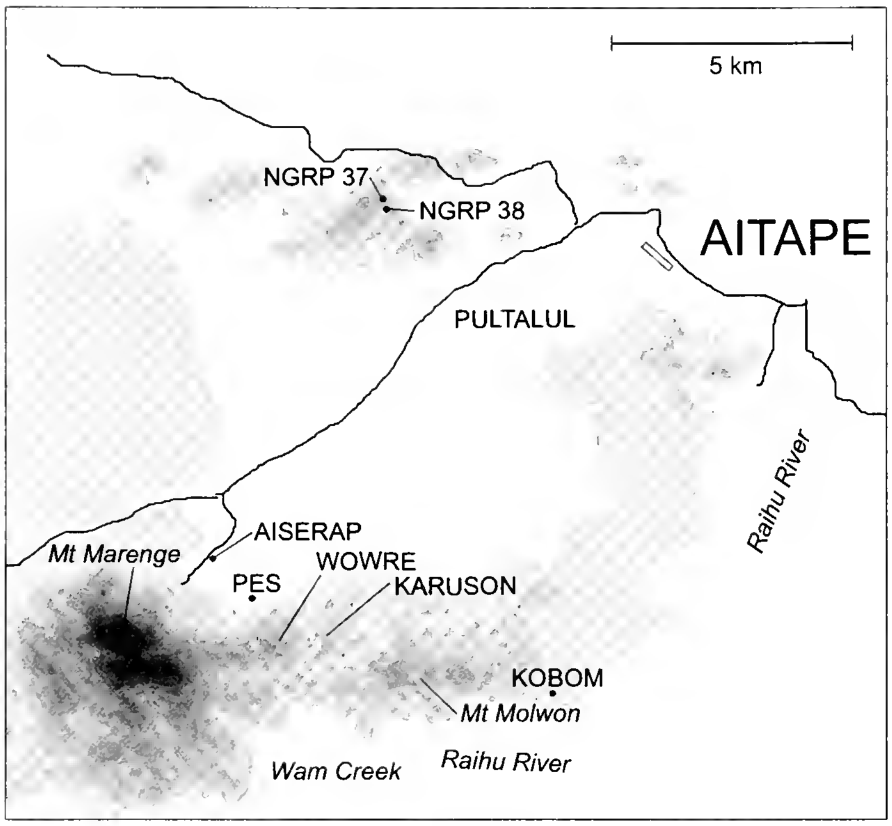

FIG. 5.26. Localities where surface collections were made in 1996.

techniques include appliqué bands and punctate appliqué bands, but there is too little visually diagnostic material to say how similar or dissimilar the finds may be to ABLP 183 and contemporary Kep-Terebu pottery making (May & Tuckson, 1982, pp. 302–307). The vicinity around the village appears to have suffered extensive bombing damage during World War II. ABLP 185 is a collection made while we were visiting there by children around Warag Village (−3.430°, 143.560°) on the western side of the island. ABLP 186 is a collection from surface midden scatter along the trail at the beachfront on the southeastern edge of Warag; while some of the sherds recovered have appliqué and punctate appliqué bands, the material is too fragmentary and limited to permit further classification. ABLP 187 is a small collection of sherds picked up off the ground along the trail connecting Warag Village with Pausum Village (−3.418°, 143,552°) on the peninsula to the northwest of Warag.

KEP (KAIEP)—ABLP 200 is a small surface collection of potsherds picked up at Kep Village (−3.636°, 143.802°), today still a major pottery-making village 21.5 km east of Wewak.

1996 Survey Work

As discussed in Chapter 3, there is reason to think that during the mid-Holocene following the stabilization of world sea levels around their current stand, the lower Aitape trough was inundated by the sea to form two shallow basins: an open bay in the west and a semienclosed lagoon in the east. The eastern lagoon was sheltered from the open sea by a chain of islands near what is today the town of Aitape (Fig. 3.3). Both basins were probably somewhat brackish (especially the eastern lagoon), given significant river inflow, and were probably not more than a few meters deep. The finds made at Aiser near Wom may indicate that at least some of the alluvial plain today south and west of Aitape may have been still lagoonal as recently as ~1,000 years ago or less.

In early October 1996 while working with us at Aitape, Glenn Summerhayes, now at the University of Otago in New Zealand, undertook a five-day survey excursion along the foothills overlooking Aiser and the rest of the Aitape plain starting at Kobom (−3.2262°, 142.3292°), where Welsch had recovered both obsidian and chert flakes in 1993 but no pottery (Figs. 5.26 and 5.27). Summerhayes was able to find both chert and obsidian flakes as well as some pottery sherds at 16 different localities, confirming that future excavations in this area of the Aitape district ought to be worthwhile. Although limited in number, the sherds suggest that this area of the coast had settlements at times when Sumalo, Aiser, and then Wain Ware was each available for use. Additionally, the recovery of obsidian and chert may hint that preceramic settlements may also be present on these hills.

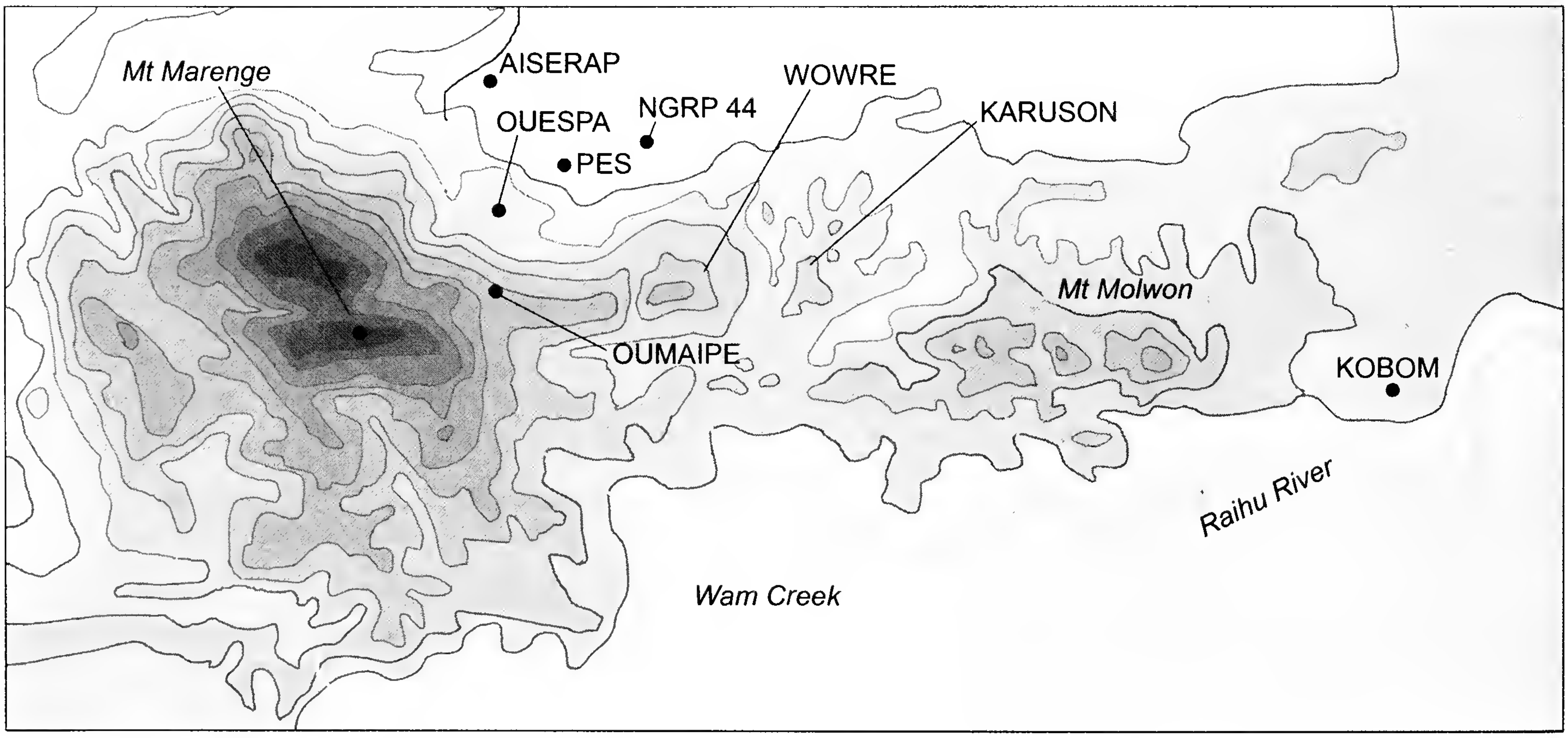

FIG. 5.27. Localities where surface collections were made in 1996 near Kobom Village.

Conclusions

Contrary to expectations that had been voiced by numerous scholars, we found no convincing evidence on the Sepik coast linking Lapita pottery in the Bismarck Archipelago directly with early ceramics in mainland Southeast Asia, Taiwan, the Philippines, or Indonesia. Nor did we find any evidence confirming that pottery making in northern New Guinea predated Lapita. What we found instead was an impressive diversity of previously unknown and unrecorded prehistoric pottery styles both locally in the Aitape and Tandanye-Walifu areas, and along the entire coastal region surveyed.

In both the Serra and the Aitape areas, it was possible to use the evidence recovered in different locales (i.e., "sites") to develop plausible ceramic sequences. Furthermore, it can now be argued that all the ceramic industries, extant and archaeological, known for this coast from Aitape to Jayapura in Papua, Indonesia, are alike derived historically from the same red-slip tradition, which on present evidence (Chapter 14) was first established on Tumleo about 2,000 years ago.

In contrast, the diversity of ceramic styles found in the Tandanye-Walifu area suggests instead that these islands have acquired their pottery vessels from a number of different production centers, both sequentially and simultaneously. Other than the suspicion that some of the finds at Simindibubu and Sareta on Tandanye resemble Lapita pottery and may thus be chronologically fairly old, it is anyone's guess how the history of these diverse pottery industries should be written. It seems likely, however, that Nyapin Ware, as evidenced on Tumleo and Ali islands and the finds at Simindibubu and Sareta, is of similar age and derivation from the Lapita tradition in the Bismarck Archipelago.

The evidence we gathered in 1993–1994, particularly at Aiser, reaffirmed the importance of seeing this coastline as a dynamic and complexly evolving landscape. The recovery of pottery sherds stylistically attributable to the Aitape area at Rainuk Airfield near Serra west of Aitape and also on Tandanye Island east of Aitape is limited but material evidence for the movement of ceramics between coastal and offshore island communities in this region of New Guinea, hinting perhaps that the friendship networks we were documenting ethnographically in 1993 date back well into prehistoric times (Chapter 15).

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Chapter 6: Archaeological Excavations

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Abstract

During September and October 1996, we completed the first archaeological excavations done in the Aitape area on the Sepik coast. The ceramic finds from our excavations on hillcrests at Aitape (which are an uplifted Pliocene/Miocene coral reef formation) suggest that human occupation in this part of the coast dates back at least to the mid-first millennium AD when Sumalo Ware (Chapters 7 and 14) was being locally made. Additionally, our excavations on Tumleo Island recovered sufficient ceramic evidence in stratigraphic position to reconstruct a fairly definitive pottery sequence for this part of New Guinea covering the last 1,500–2,000 years.

Introduction

With funding from the National Science Foundation ("The Archaeology of Exchange Networks in the Aitape District of Papua New Guinea," grant SBR-9506142), we carried out the first archaeological excavations done at Aitape during September and October 1996.

The primary field research team comprised Baiva Ivuyo, Robert Mondol, Glenn Summerhayes, Michael Therin, Rob Welsch, and myself. Welsch was scheduled to carry out an intensive field survey of possible archaeological sites in the foothills south of Aitape and Sissano Lagoon in search of mid-Holocene and earlier settlement locations. Unfortunately Rob broke a leg at Wewak while en route to Aitape, and Glenn Summerhayes was able to complete only a few days of reconnaissance in the Kobom area in the Raihu River area (below and Chapter 5).

We undertook this archaeological expedition to Aitape in 1996 with three principal goals in mind:

1. Carry out stratigraphic excavations to test and improve the resolution of our proposed ceramic sequence for the Aitape district based on the surface collections we made in 1993–1994
2. Recover charcoal or other datable material from stratigraphic contexts to develop a radiocarbon chronology for key points in the Aitape ceramic sequence
3. Test the inference derived from our 1993–1994 survey work that modern pottery making in the Aitape district is the contemporary expression of an enduring local craft tradition dating back to the beginning of pottery making in this part of New Guinea

Research Issues

While we considered each of the localities we had surveyed in 1993–1994 (Chapter 5) to be promising for further archaeological research and excavation, we limited our work in 1996 to the Aitape district, where we had based most of our ethnographic research in 1993–1994. Several interrelated research issues prompted these new archaeological investigations.

Pre-Lapita Pottery Making in New Guinea?

Our survey work in 1993–1994 led us to the working hypothesis that Lapita pottery (Terrell & Schechter, 2009) is mostly, if not entirely, absent on the Sepik coast. Furthermore, in view of what Pamela Swadling and Paul Gorecki seemingly had each found elsewhere in northern Papua New Guinea (Chapter 4), we wondered whether there might once have been pottery-making traditions in the Aitape area older than the well-known Lapita tradition in the Bismarck Archipelago. Said differently, we wondered whether Lapita had been only one of perhaps several historically interrelated pioneering ceramic traditions in Irwin's voyaging corridor between Asia and the Bismarcks marked by the production of plain and red-slipped globular pots (Solheim, 1964; Golson, 1972, pp. 577–581; Bellwood, 1985, pp. 223–228, 252–253, 1992, pp. 50–51; Bellwood & Koon, 1989, pp. 618, 621; Spriggs, 1989, pp. 605–609, 1993, p. 193; Butler, 1994).

Prehistoric Exchange

In light of our 1993–1994 work, we also wondered how long ago trade and travel between places on the Sepik coast and elsewhere in Irwin's voyaging corridor (Chapter 4) had been going on before pottery making as a local craft was established there. Are the far-reaching social and economic networks among communities that have been so prominently part of life here during historic times (Chapter 15) only recent developments—perhaps even just an outcome of German and later Australian pacification? Alternatively, were people on this coast and on the nearby offshore islands more or less

FIG. 6.1. Excavating on Mount Mario overlooking Aitape and the Bismarck Sea, September 1996.

effectively isolated from one another at least until the arrival of Austronesian-speaking people with superior canoe-making skills, as the German ethnologist Frank Tiesler had inferred (Chapter 4)? Or, as we ourselves suspected, had people on this coast always been in contact with one another regardless of how impressive or rudimentary their canoe-making talents or voyaging prowess?

Continuity Hypothesis

We also hoped to learn whether the history of pottery making in the Aitape area is a record of more or less continuous local production and stylistic development, as we suspected on the basis of our provisional 1993–1994 survey work, or, alternatively, reflects changing patterns of trade from different production centers located elsewhere in the voyaging corridor.

Kobom Hypothesis

If our working understanding of the geomorphologic history of the Aitape coast since the end of the Pleistocene is reasonably correct (Chapter 3), then archaeological sites older than 6,000–7,000 years are most likely to be found on the higher ground inland at varying distances from the present coastline. One hilltop site yielding worked chert and obsidian—but not pottery—was located by Welsch in 1994 near Kobom village (−3,2262°, 142.3292°; Figs. 5.26 and 5.27) overlooking the Raihu River. Given its location and the apparent absence of pottery there, it seemed reasonable to suspect that this site might be older than any of the pottery-bearing sites we had found along the coastline. Hence, the Kobom locality not only seemed to be a promising area for additional exploration in 1996 but also—when viewed in conjunction with the find spot of the famous Aitape skull at a similar inland location behind Sissano Lagoon (Chapter 4)—suggested that survey work in 1996 along the foothills behind Aitape might lead to the discovery of other possible mid-Holocene and earlier settlement locations (see 1996 Survey Work in Chapter 5).

Excavations

Our 1993–1994 archaeological survey results suggested that reasonably intact stratified deposits of some depth with materials dating back to the time of Sumalo Ware (Chapters 7 and 14) or earlier might be found through excavation on Tumleo Island near Sapi hamlet. The recovery of numerous sherds of Sumalo Ware at Sumalo Hill on the mainland at Aitape similarly suggested that excavation there might also be worthwhile. Although a single Lapita potsherd had been found in Turale hamlet on Ali Island in 1993 (Chapters 5 and 13), both the apparent shallowness of the soil on this island and the extent of present-day usage of the Turale area

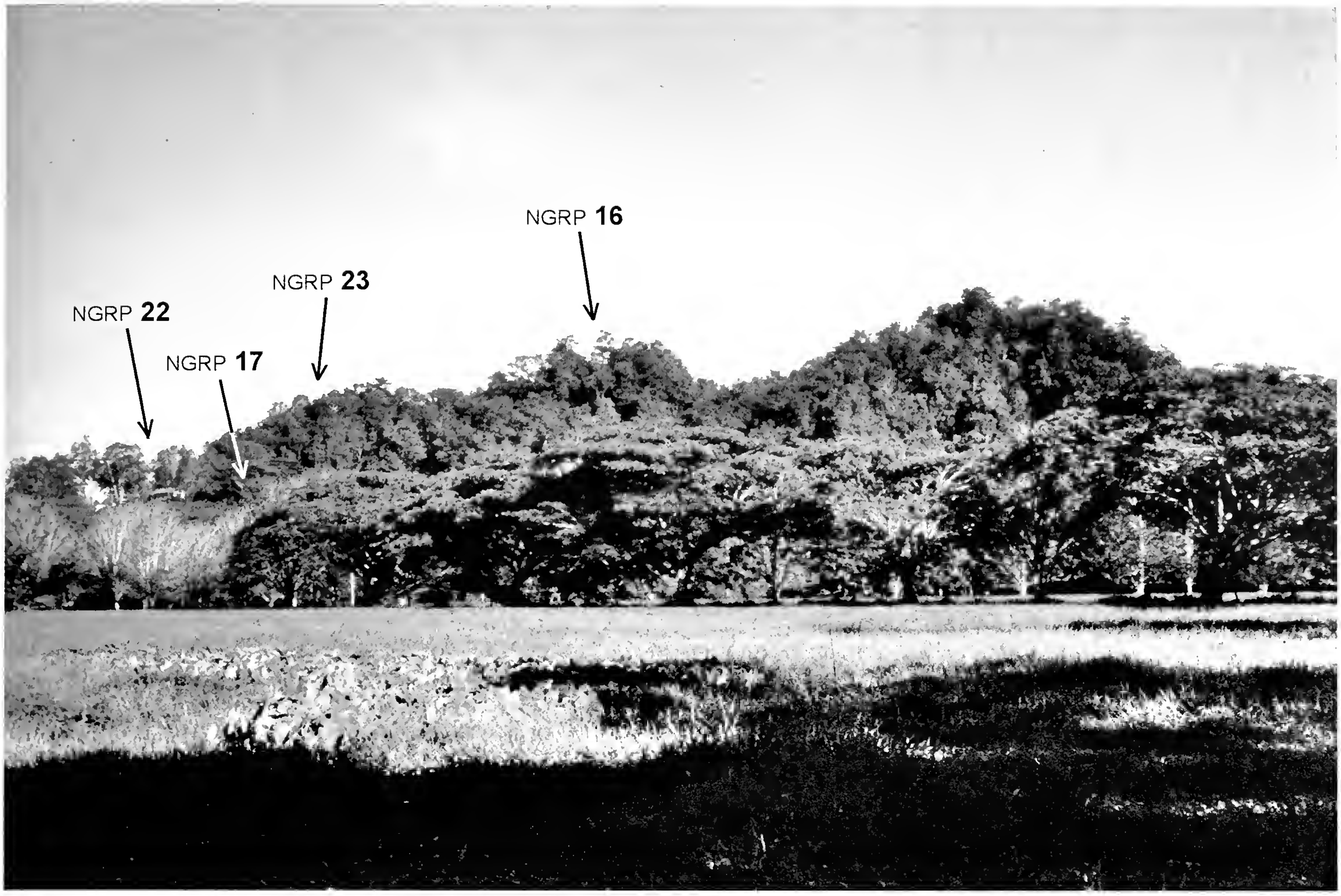

FIG. 6.2. Ridge crests of the upraised reef formation south of Aitape at the Roman Catholic Mission school and plantation showing the approximate location of NGRP 17 and the excavations at NGRP 16, 22, and 23 in 1996 (from 35-mm color slide by Michael Therin).

suggested that finding well-stratified and reasonably undisturbed deposits on Ali would be problematic. Considering the evident extent of wartime destruction on Seleo Island during the early 1940s, that island also seemed less promising for excavation, as did neighboring Angel Island because of its small size and the apparent recency of its emergence above sea level.

Between the middle of September and the end of October 1996, we completed 14 test excavations ranging in areal size from 50 × 50 cm to 300 × 300 cm on the crests of the low foothills on the southeastern side of Aitape (Figs. 6.1–6.3). Evidently because of the shallowness of the extant soil development and the chemical destructiveness of tropical weather, only two of these mainland excavations (NGRP 16 and NGRP 23) yielded well-preserved ceramic finds as well as shell (mostly brackish and fresh water lagoonal species; see Chapter 11) and bone (both human and animal; see Chapter 10). Additionally, three 100 × 100-cm test pits 10 m apart reaching a maximum depth of ~168 cm below the present land surface were excavated on Tumleo Island 4 km off the Aitape coast (Fig. 6.11).

Sumalo Hill and "Mount Mario"

On 20 September before the rest of us had arrived at Aitape, Michael Therin was able to excavate three 50 × 50-cm test squares on the top of Sumalo Hill overlooking the road-metal quarry (Chapter 5). In two of these exploratory units, he reached depths of 60 cm before stopping; in the third, the depth reached was approximately 40 cm. The soil profiles he observed graded from dark humic brown clayey loam at the top through light brown soil of similar composition and then yellow-brown soil, again of similar character. Only one potsherd was found. It seemed quite weathered and rolled, reaffirming his assessment that these soils might be attributed largely to slope wash. Additionally, according to Rob Parer, a longtime resident at Aitape, Sumalo Hill had been heavily damaged during World War II. Therin concluded that further excavation in the immediate vicinity of Sumalo Hill would probably be fruitless. The following day he put down a fourth 50 × 50-cm test square that reached a depth of almost 90 cm on the small knoll by the beach directly across from Sumalo Hill, but with similarly unpromising results.

In light of these negative findings, we relocated our efforts farther away from Aitape, although we kept to the hills of the same upraised limestone reef formation after additional ground survey had determined that most of the flat alluvial land around Aitape not only is recent in origin, but still subject to frequent flooding during the rainy season.

The elevated ridge crests immediately overlooking St. Ignatius Secondary School 2 km south of the shoreline at Aitape, which reach heights of 40–50 m above the surrounding alluvial flats and which are known at the Roman Catholic Mission as "Mount Mario," were covered largely in low scrubby bush and dense *kunai* grass (*Imperata cylindrica*) in 1996. We opened a series of 50 × 50-cm to 2 × 2-m test squares along the ridge crest overlooking the school grounds

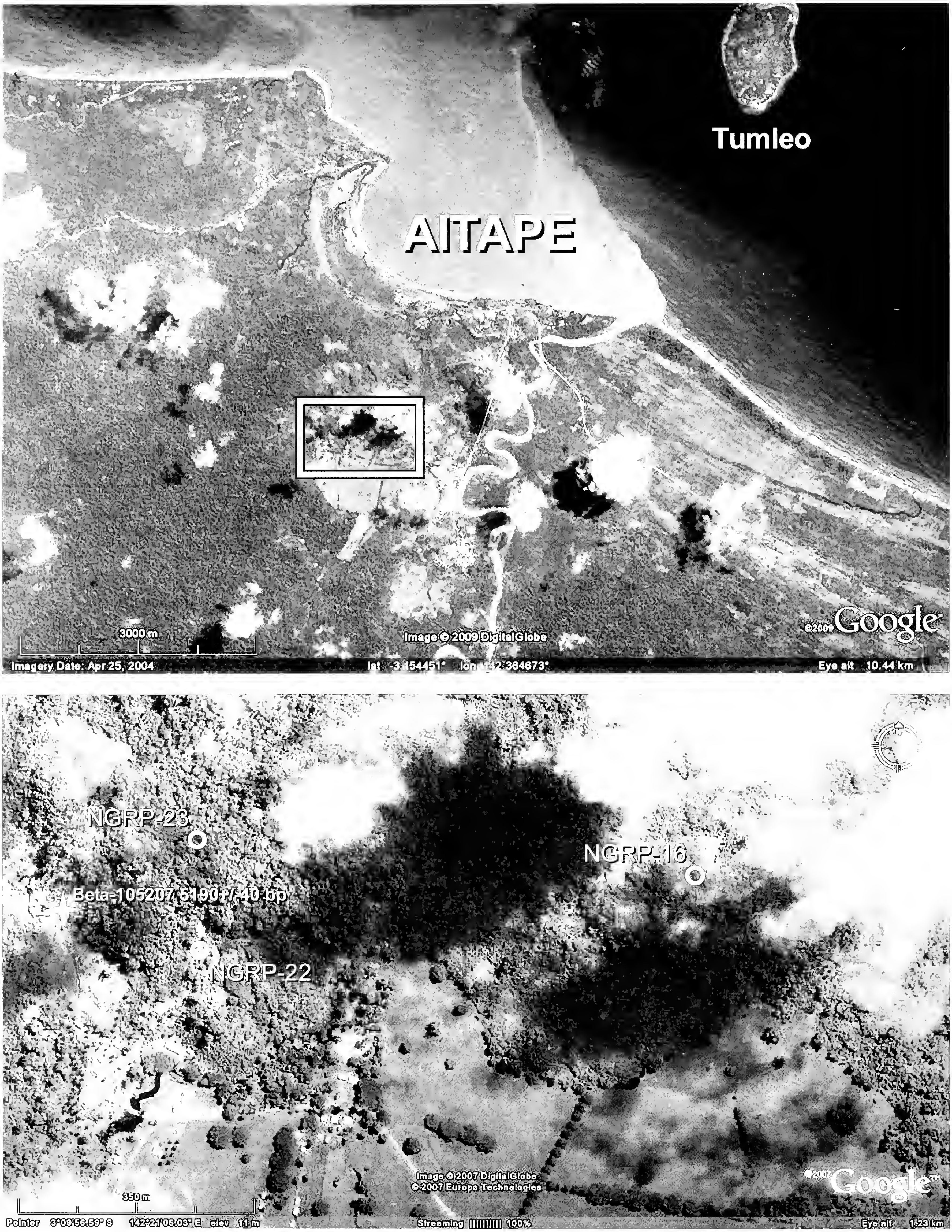

FIG. 6.3. Locations of NGRP 16, 22, and 23 (imagery © Google.com).

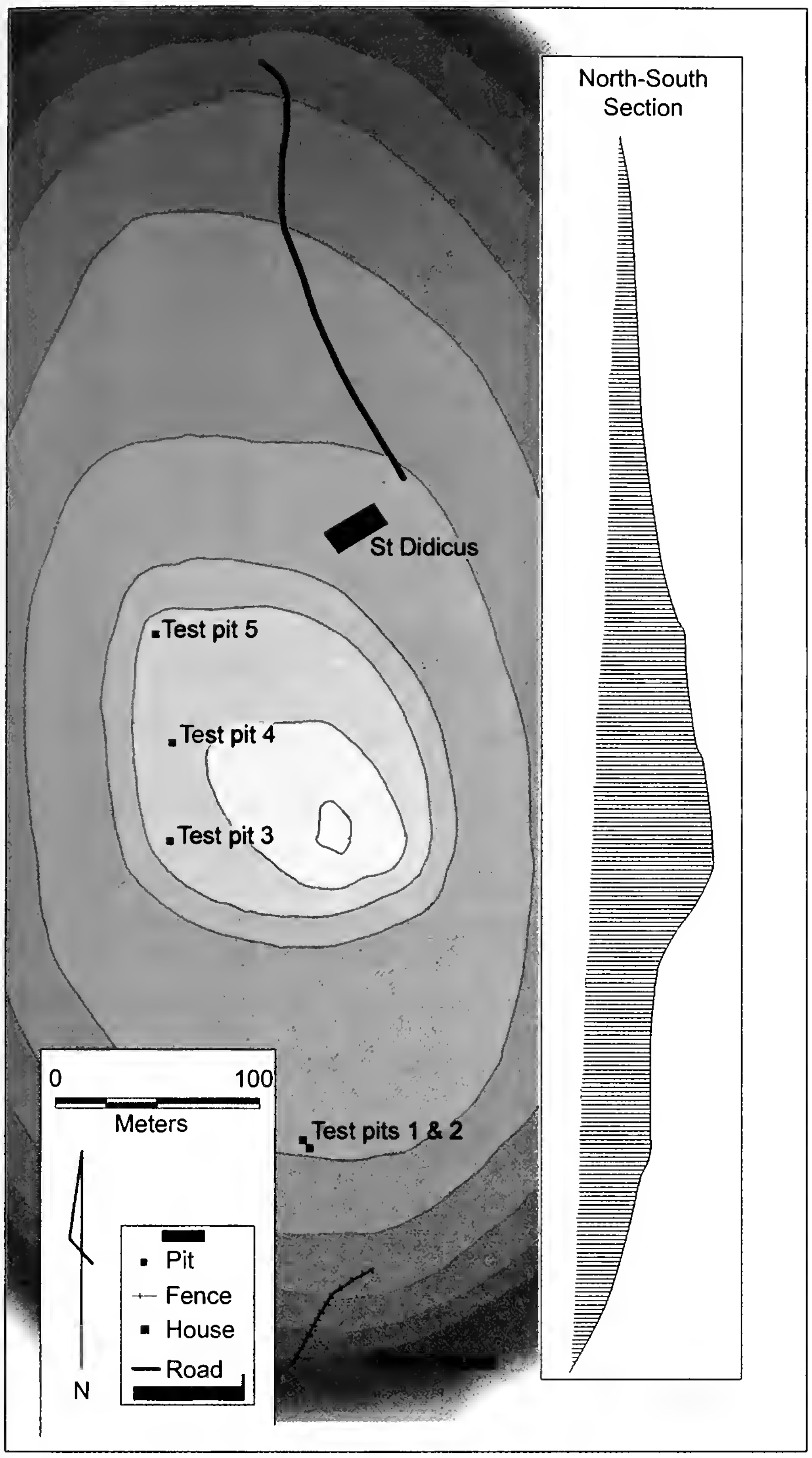

FIG. 6.4. Test pit excavations on the elevated ridge crests (locally known as "Mount Mario") overlooking St. Ignatius Secondary School 2 km south of the shoreline at Aitape.

for a distance of approximately 250 m between −3.1666°, 142.3600°, and −3.1643°, 142.3599° (Fig. 6.4).

The stratigraphic profiles in these test pits consistently showed a compact, stony, very dark brown clay loam becoming somewhat lighter in color and more crumbly, or "sandy," in texture, overlying and tonguing into the limestone bedrock of the ridge system at a depth of ~50–75 cm (see Haantjens, 1972, p. 230). The potsherds recovered from the dark brown clay loam were initially described by those excavating them as "rolled"; that is, their rounded edges seemed to indicate that they had been physically eroded, and hence they were in secondary position relative to wherever they had originally been deposited. Closer inspection revealed, however, that in many cases the erosion has been chemical rather than physical: the outer surfaces of sherds in this soil horizon have been dissolved chemically into the surrounding clay matrix. In some instances, it was possible to detect a "ghost" profile in the soil of what a sherd had originally looked like—sometimes with the red clay slip on what had once been the surface of the sherd still in evidence as a thin red line of coloration in the soil around the surviving but now highly "eroded" ceramic core of the original sherd.

Another consequence of such intense chemical degradation is that no bone and very little shell were recoverable from these test squares, although occasional flakes of chert and obsidian were recoverable from the upper ~20–30 cm—evidently also the major zone of intense chemical in situ "weathering."

INTERPRETATION OF RESULTS—The recovery of potsherds, chert flakes, some obsidian flakes, and other seemingly exotic types of stone on Mount Mario attests to the former use of these ridge crests at a time when Sumalo Ware was available in the Aitape area (Table 6.1). Unfortunately, however, as on Sumalo Hill at Aitape, conditions of preservation have generally been extremely poor. Somewhat like deep plowing in the American Midwest, chemical degradation over time has largely stripped the upper dark brown clay loam horizon of all but the most imperishable signs of human activity. Although no post molds or other archaeological signs of prehistoric dwellings or other structures were found during the 1996 excavations, it is conceivable that extensive area excavations might be able to locate posthole alignments, hearth areas, and the like below this astonishingly destructive chemical "plow zone."

NGRP 16

The crests overlooking the fields of the Mission plantation west of St. Ignatius Secondary School are covered mostly in low trees and a dense carpet of partially decomposed organic matter (Figs. 6.2 and 6.3). Hiking up and down from crest to crest over this old upraised reef formation in search of promising areas for excavation had to be done for the most part along existing pig and goat tracks through the bush because of the density of the forest cover. On 26 September, however, Baiva Ivuyo and I were able to locate three separate areas that from surface appearances looked worthy of closer study, areas we designated as NGRP 16, NGRP 22, and NGRP 23 (Fig. 6.3).

EXCAVATION—During the second week of October, we excavated a 3 × 3-m test pit in three rows of 1 × 1-m adjacent squares designated A-1–C-1, A-2–C-2, and A-3–C-3 at NGRP 16 (Figs. 6.5 and 6.6). The ground was removed using both stratigraphic changes in soil color and texture and also in unit levels ("spits") within these profile horizons to record and bag the finds recovered. Limestone bedrock was reached at depths of only 20–41 cm. The visible stratigraphic layering of the deposit was largely noncultural; that is, the zones observed were judged to be indistinguishable from what might be seen in a culturally unmodified weathering profile. However, layers B and C contained dense and jumbled scatters of tabular limestone blocks in secondary position; that is, the blocks had obviously been brought from somewhere else and dumped where we were finding them. They were not the result of in situ bedrock weathering (see Layer E below):

Layer A: A thick mat of only partially decayed organic matter containing no in situ cultural material.

Layer B: Dark brown soil with numerous pebbles, flat tabular blocks, etc. of limestone. There was an observable concentration of scattered human bone toward the bottom of the layer in the northeast corner of square A-1 along with

Table 6.1. Stratigraphic distribution of potsherds in the excavations on "Mount Mario."

Date	Test pit	Spit	Total sherds	Decorated sherds	Sumalo	Incised	Lip sherds	Notched lips	Everted rim	Neck collar
9/25/1996	1	1	10							
9/25/1996	1	2	7							
9/25/1996	1	3	1							
9/25/1996	1	5	2							
9/26/1996	2	2	1							
9/26/1996	3	1	19	1	1				1	1
9/27/1996	3	2	4							
9/28/1996[a]	4		5							1
	4	1	62	1	1	1	8		2	1
9/27/1996	4	2	25	1	1					1
9/27/1996	4	3	27							
9/28/1996	4	4	5							
9/27/1996	4	4	8							1
9/27/1996[b]	5/A	1	78				6		4	4
9/27/1996	5	2	179	6	6		5		6	7
9/28/1996	5	3	83				1			4
	5/A	3	1				1		1	
9/30/1996	5/A	4	23							
10/1/1996	5/B	1	38	1	1					1
10/1/1996	5/B	2	68				6	1	5	8
9/30/1996	5/C	1	21				2			1
	5/C	2	57	2			2		2	1
10/1/1996	5/C	3	44	1	1		1			1
9/30/1996	5/D	1	27				1		1	
9/30/1996	5/D	2	15				1		1	
10/1/1996	5B	4	13							
10/1/1996	5C	4	35	1			3		2	
10/1/1996	5D	3	36	1	1		1		1	
9/30/1996	5E	1	31				1		1	
Totals			**925**	**15**	**12**	**1**	**39**	**1**	**27**	**32**

[a] Surface.
[b] North ridge.

some obsidian. Some shell and bone, including human teeth, were recovered from square A-3.

Layer C: Lighter brown soil with numerous pebbles, flat tabular blocks, etc. of limestone. Most of the bone and shell recovered from layer C came from the northwest corner of square A-3 jumbled in between numerous tabular blocks of limestone.

Layer D: Still lighter brown soil with numerous limestone pebbles, etc. Little artifactual material found.

Layer E: Limestone bedrock that has weathered in situ into regularly layered tabular blocks dipping at about 45° from the vertical (quite unlike the jumble of limestone blocks removed from layers B and C).

Interpretation of Results—Given the limited scale of this excavation, it is not possible to infer much about how this ridge crest was being used when the human remains and cultural materials were being discarded where we found them. Robert Mondol and I (who were both chiefly responsible for this excavation) each independently concluded that we were probably dealing with a stone and refuse dump beside a small house or settlement clearing. It was obvious that we were not finding complete human skeletons or conventional burials, and that the bone fragments we were finding had basically been discarded among the stones in this dump, or "stone midden" (which contained blocks of stone so numerous that it was particularly difficult to excavate layers B and C).

Insofar as one may judge by appearances, therefore, the word "discarded" rather than "interred" or "buried" would seemingly best describe the character or condition of the human remains found at NGRP 16 (but see Chapters 10 and 15). In keeping with this inference, the potsherds recovered (Table 6.2) are mostly so small that a label such as "fragments" or "bits" rather than "sherds" or "shards" conveys a better sense of the shape they are in—much like what one might imagine routine ground sweepings from some well-trodden living area nearby would probably look like; that is, in all likelihood, this dump had probably been seen as simply a good place to discard the sweepings collected while maintaining the grounds of the hamlet—not a "kitchen midden," or primary refuse dump, in the conventional archaeological sense.

All the ceramic material recovered at NGRP 16 (Table 6.2) can be attributed to Sumalo Ware (Chapter 7), suggesting that significant use of this locale for settlement occurred only when this ware was available in the Aitape area (Chapter 14).

NGRP 22

During survey reconnaissance on 2 October, numerous potsherds were found eroding down the eastern slope (later designated as NGRP 17) of the ridge crest locally called St. Martin's at the western end of the Mission plantation (Fig. 6.3). Although the sherds collected were strongly weathered and were clearly eroding down this slope, the range of vessel forms (Table 6.3) and the comparative abundance of finds encouraged us to undertake an exploratory excavation on the ridge crest above at a location ~50 m north-northwest from the Nuns' Quarters at St. Martin's.

A 1 × 2-m test pit subdivided into two 1 × 1-m squares—later expanded to include another 1 × 1-m square on the

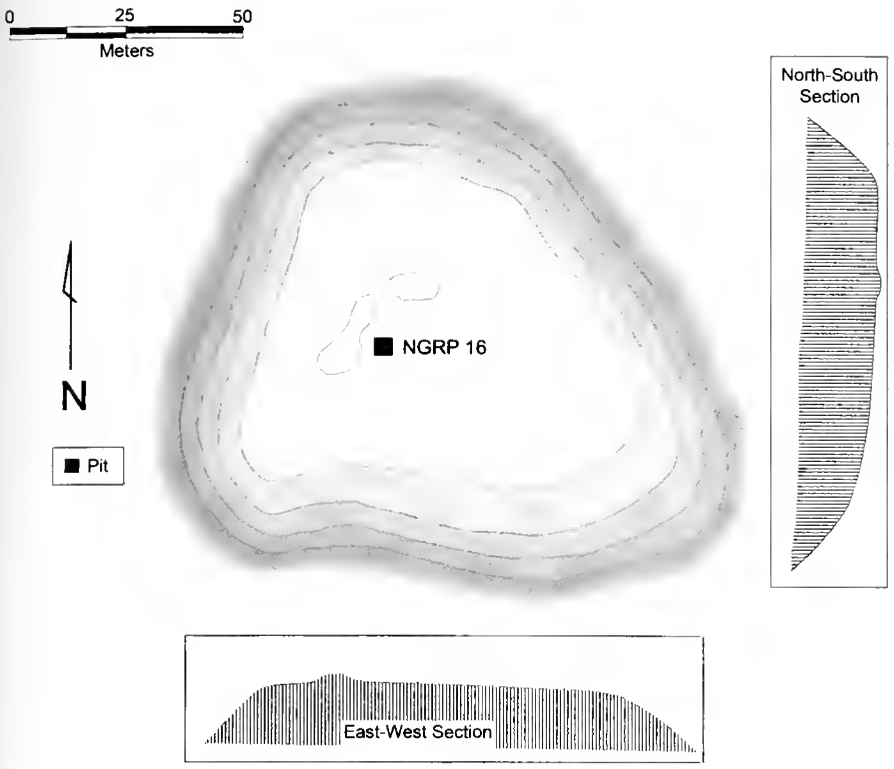

FIG. 6.5. Excavation at NGRP 16.

southern side of the eastern square of the original pair—was excavated to a maximum depth of ~75 cm by Alois Kuaso from the University of Papua New Guinea, with others assisting. Although 155 potsherds had been found in the gardens and elsewhere nearby at St. Martin's during surface survey prior to excavation that indicated use of this ridge crest at a time when Sumalo Ware was locally available, only 115 additional potsherds as well as some obsidian and chert flakes were recovered through excavation. Of the ceramic finds, all are undecorated body sherds except for a single triangular rim sherd (Table 6.3). As at Mount Mario, significant in situ chemical weathering of stone and ceramics was observed during excavation, but judging by the depth of the deposit removed, slope wash deposition from higher up the ridge crest has probably also been a contributing factor in the genesis of soil overlying the limestone bedrock of the underlying ridge system here (which was encountered at the bottom of the excavation).

NGRP 23

As noted previously, surface survey at the end of September located three promising locales for excavation on the ridge crests overlooking the Roman Catholic plantation and St. Ignatius Secondary School south of Aitape: NGRP 16, NGRP 22, and NGRP 23. The latter is on the ridge crest immediately above St. Martin's, NGRP 22 (Fig. 6.3). Two subsurface probes, one to a depth of 50 cm and the other to 60 cm, revealed that bone (including human bone) and shell, as well as pottery and flakes of chert and obsidian, were present beneath a ~10-cm dense surface mat of organic matter. Under the supervision of Michael Therin, a 75 × 125-cm excavation was then undertaken in a natural trough of limestone and sedimentary rock on the very top of the ridge (Figs. 6.7–6.10):

Layer A: Dense surface mat of roots and organic matter mixed into a dark brown/gray humic loam; no cultural material.

Layer A1: Dark brown/gray humic loam with numerous roots; shell, bone, chert flakes, and potsherds began to occur at the base of this horizon.

Layer B: Gray-black loose soil; degraded (i.e., decomposing) wall of the natural limestone trough in which these horizons have developed started to appear along the northern side of squares A and B with the removal of this stratum; pottery, bone, shell, chert, obsidian, and charcoal; potsherds notably abundant in the center and southern side of square A; the remains of six pig mandibles were removed from this layer in square C.

Layer C: Similar to layer B but lighter in color and mottled with fragments of degraded coral limestone; pottery, bone, shell, chert, obsidian, and charcoal; while fragmented, the frequency of human bone was notable enough to suggest the presence of a formal burial; 25 × 50-cm squares C and D—and later 25 × 25-cm square E—were added to the area being excavated to explore this possibility. Recovered from square E in this layer were six human long bones aligned with one another east to west, the orientation of the natural stone trough in which they were deposited. Associated with these seemingly "bundled" bones were two human mandibular fragments and an incised dog's tooth; additionally, nine perforated dog's teeth were recovered from square A, and other long bone fragments were found in the northeastern corner of square C as well as in the center of square B.

Layer D: Coarse gray sandy loam with numerous inclusions of limestone and sedimentary rock fragments mostly smaller than 2 cm in size; while the northern side of the natural V-shaped trough that has preserved this diverse range of cultural material is crumbling limestone, the southern wall is a similarly decomposing sedimentary layer so friable that it was easily dug through. Except for two pieces of bone and a fragment of shell removed from square B probably derived from layer C, layer D proved to be devoid of cultural material.

INTERPRETATION OF RESULTS—Especially in view of the restricted scale of the excavation at NGRP 23, the range and abundance of archaeological finds in comparison with all the other excavations undertaken in 1996 are noteworthy. Equally significant is the absence of subsequent soil deposition: the archaeological finds are well preserved and were encountered immediately below a thin topsoil. A shallow exploratory probe dug into the relatively flat surface of the ridge crest beyond and south of the V-shaped natural stone trough revealed that the soil profile beyond this trough was comparable to that encountered at Mount Mario and at NGRP 22. It seems apparent, therefore, that the conditions of preservation inside this natural trough are both fortuitous and rare for this locale.

As elsewhere on these irregular ridge crests south of Aitape, the ceramic finds recovered here indicate that discernible human use of this rugged location dates to the time when Sumalo Ware was locally available (Table 6.4). In light of the good condition of the bone in particular (Chapter 10), much of its fragmentation may be postdepositional in origin, unlike NGRP 16—both pigs and people (and more recently goats) have probably been walking down this trough for countless years. Also unlike NGRP 16, the range and condition of the materials recovered suggests that this trough was used as a refuse dump in Sumalo times, that is, a midden in the conventional archaeological sense of the term.

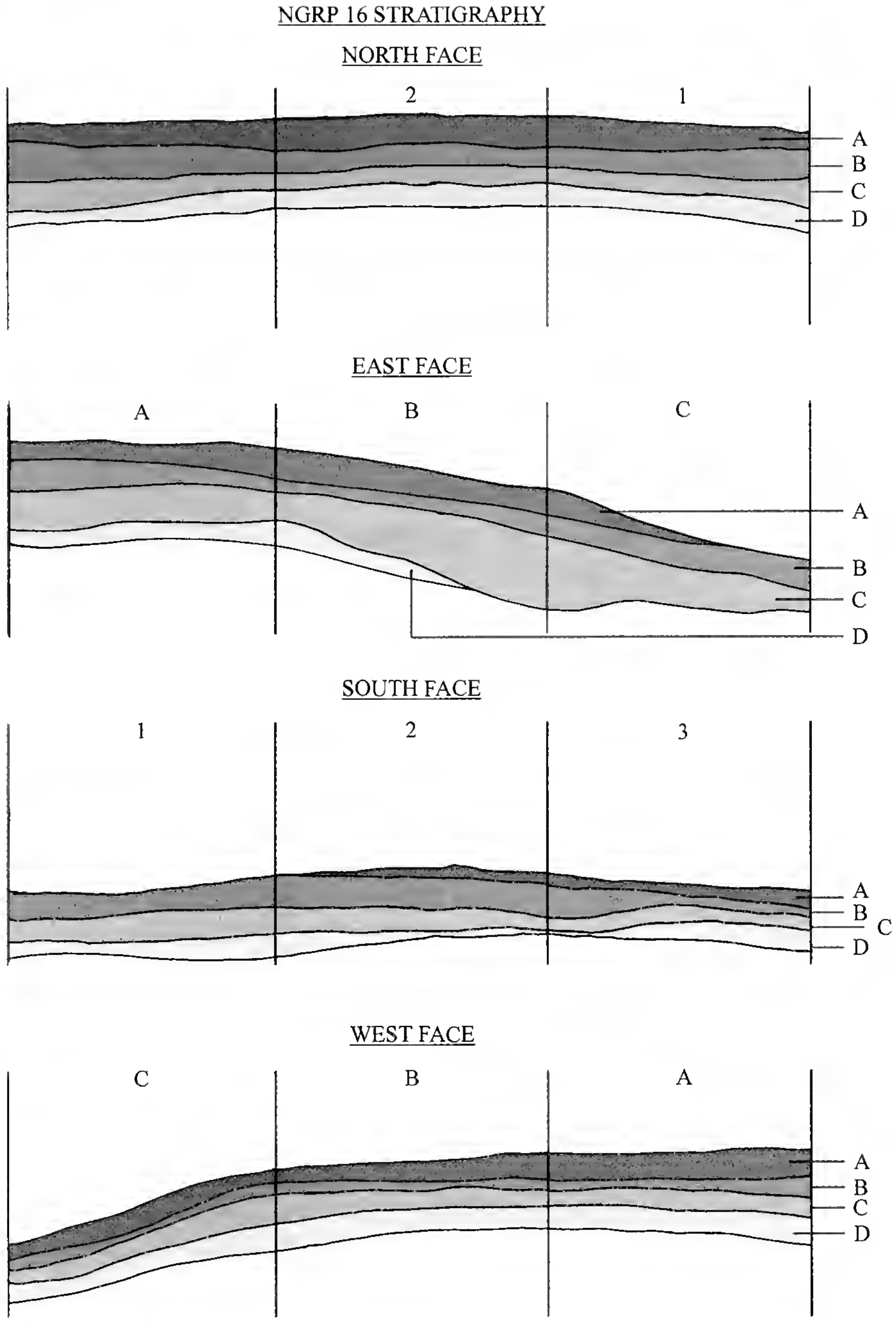

FIG. 6.6. Stratigraphic profiles at NGRP 16.

NGRP 46

Three 1 × 1-m test pits 10 m apart reaching a maximum depth of 168 cm below the present land surface were excavated on Tumleo Island 4 km off the Aitape coast (Fig. 6.11). All three of these excavations produced cultural and faunal materials in stratigraphic position. We observed little disturbance or mixing of the finds other than root intrusions.

TEST PIT 1—This test pit was set out and initially excavated as a 1 × 3-m unit subdivided into three 1-m squares (1A, 1B, and 1C) with the long axis aligned along magnetic north. The southwestern corner of square 1A at the southern end of the unit was 3.5 m away at 4° east of magnetic north from the cement marker at the northeastern corner of the Mission graveyard at Nyapin (Chapter 5). All three squares of the unit were excavated in stratigraphic layers identified by soil color and texture together with arbitrary 10–15-cm "spit" subdivisions within these soil divisions (Fig. 6.12). In view of the abundance of pottery in layers 1 and 2, the decision was made for strategic reasons by Baiva Ivuyo, the lead archaeologist on this excavation, to dig only square A below layer 2, spit 2—the chief reason being the difficulty of transporting archaeological materials out of Aitape by small plane:

Layer 1, spits 1 and 2: Very dark brown humic sandy loam; a somewhat disturbed surface horizon with pottery sherds, chert flakes, obsidian flakes, shell, and modern bottle glass.

Layer 2, spits 1–3: Brown/gray sandy loam; sherds abundant in the first two spits, some obsidian, chert, bone, and shell, some chunks of coral limestone.

Layer 3, spits 1–3: Brown sand; less abundant pottery, no obsidian, bone, and shell.

TABLE 6.2. Stratigraphic distribution of potsherds at NGRP 16. Note that only 1% of the sherds are decorated.

Square	Layer	Total sherds	Sumalo	Notched lips	Triangular lips	Everted rims	Neck collars
A1	A	10					
A1	B	68	1			1	
A1	C	63	2				
A1	D	45					
A2	A	5				1	
A2	B	7				1	
A2	C	6					
A3	A	2					
A3	B	31					1
A3	C	73					1
A3	D	6					
B1	B	20		2		1	
B1	C	27					
B1	D	24					
B2	B	54	1	1		1	2
B2	C	72	1				1
B2	D	33					
B3	B	12		1	1	1	
B3	C	4					
B3	D	3					
C1	B	9				1	
C1	C	1					
C2	B	10					2
C2	C	28		1			2
C3	B	35					
C3	C	38	1				
C3	D	116	1			1	1
Probe #1		22					
Probe #2		15					2
Surface		107	2		1	10	14
Totals		**946**	**9**	**5**	**2**	**18**	**26**

TABLE 6.3. Distribution of potsherds and decorative ceramic attributes at St. Martin's, NGRP 22, and in the surface collection made at NGRP 17.

Square and layer	Spit	Total sherds	Sumalo (D-21)	Triangular lip	Decorated triangular lips	Everted rim	Neck collars	Carination
Surface		155	4		1	12	4	
1A	2	19		1				
1A	3	37						
1A	4	1						
1A	6	1						
1B	2	8						
1B	3	6						
1B	5	5						
1C	1	4						
1C	2	13						
1C	3	10						
1C	4	6						
1C	5	3						
1C	6	2						
Totals		**270**	**4**	**1**	**1**	**12**	**4**	
NGRP 17		**155**	**12**	**5**	**4**	**35**	**59**	**7**

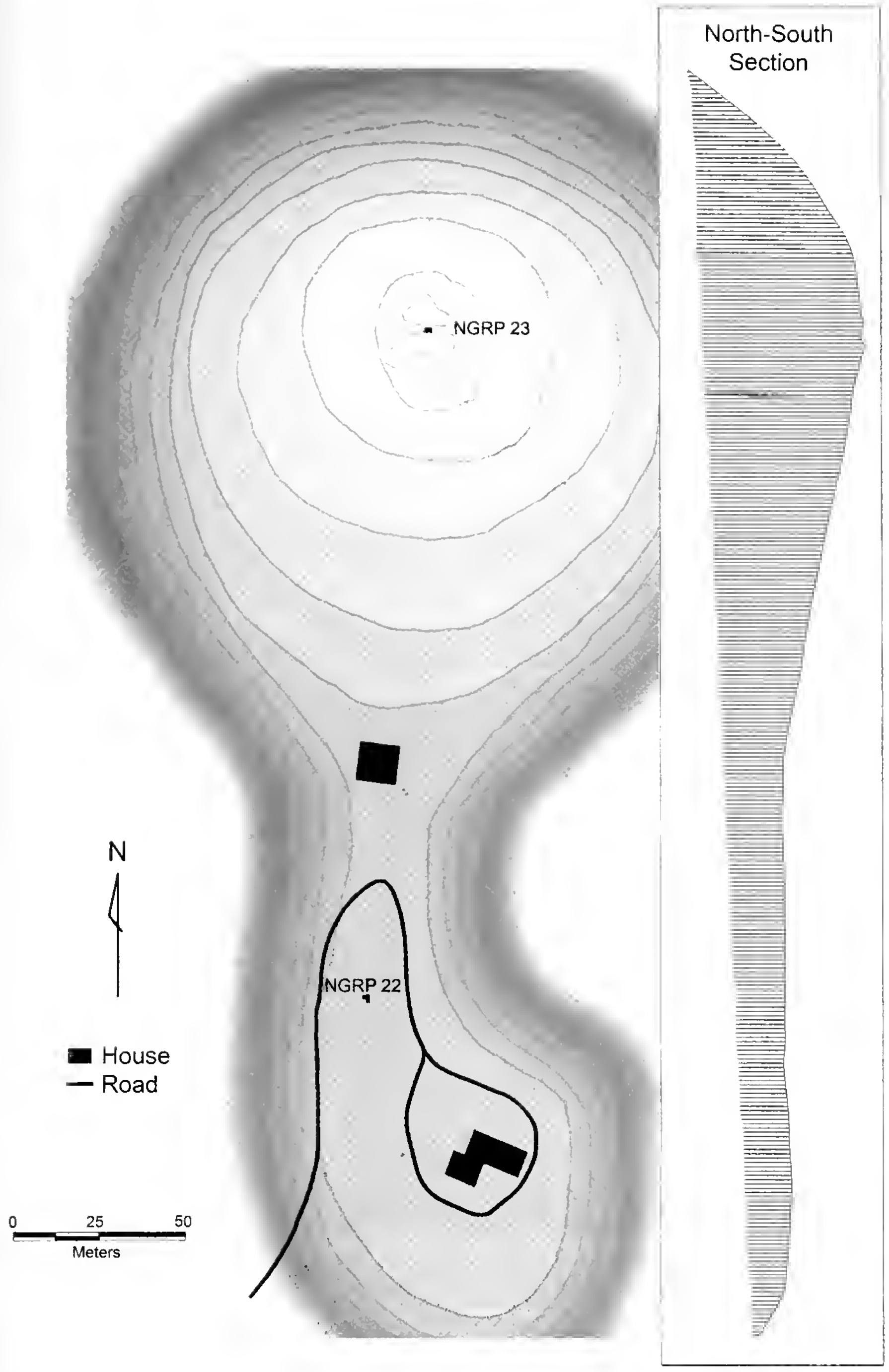

FIG. 6.7. Excavations at St. Martin's.

Layer 4, spits 1–3: Light brown sand; some pottery, bone, and shell, but only one piece of obsidian.

Layer 5, spits 1 and 2: Light yellow brown sand and beach shell; some pottery, obsidian, and other cultural material in spit 1 but no cultural material was found in spit 2; maximum depth reached before stopping excavation in yellow/white sand: ~168 cm below ground surface.

INTERPRETATION OF RESULTS—Based on stylistic analysis of the potsherds recovered from these stratigraphic units (Chapter 7), Wain Ware predominates in layer 1, Aiser Ware

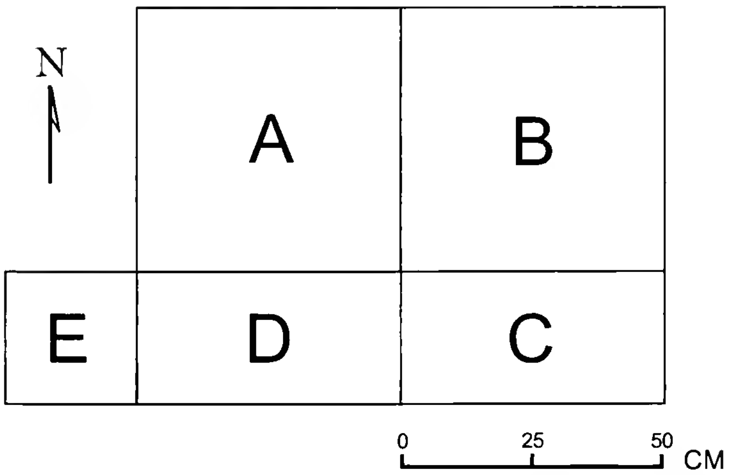

FIG. 6.8. Areal plan of the excavation at NGRP 23, St. Martin's.

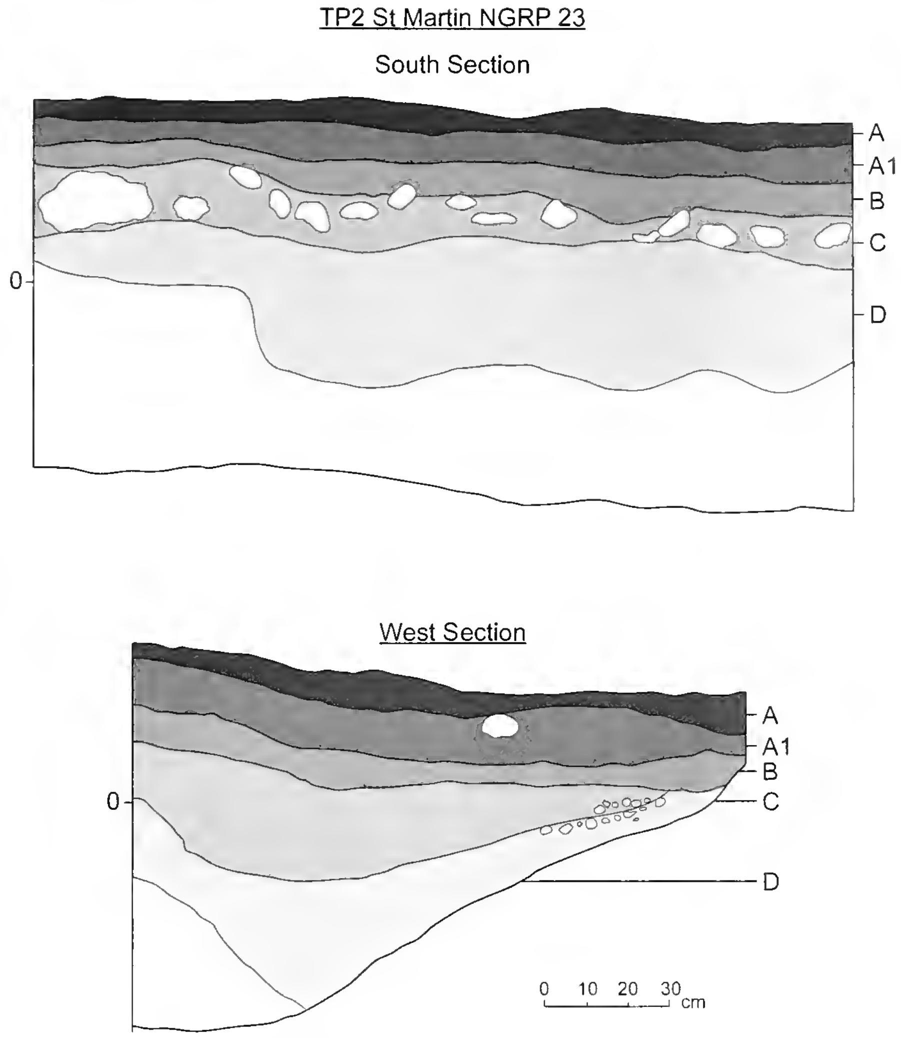

FIG. 6.9. Stratigraphy in the excavation at NGRP 23, St. Martin's.

in layer 2, and Sumalo Ware in layers 3 and 4 (Fig. 6.12). The sherds found in layer 5, spit 1, are too generic to be assigned to a ware, but may presumably be attributed to Sumalo Ware. Therefore, while only differences in soil color and texture were used during excavation to distinguish these several stratigraphic layers, they evidently have cultural and chronological significance (although the actual formative circumstances leading to the progressive deposition of sand in this area are unknown).

TEST PIT 2—The northwest corner of this 1 × 1-m square was 10 m south and 29° southeast of east from the southeast corner of test pit 1 (Fig. 6.13):

Layer 1, spits 1 and 2: Dark brown humic sandy loam becoming lighter brown toward the bottom of the layer; pottery, shells, obsidian, and bone.

Layer 2, spits 1–5: Lighter brown sandy loam; pottery, obsidian flakes, stones, bone, and shells.

Layer 3, spit 1: White beach sand with numerous beach shells but devoid of cultural material; along the northern wall of the excavation, however, one obsidian flake and a little pottery were found in an intrusion of uncertain derivation filled with gray sand and tree roots; maximum depth below ground surface excavated in yellow/white sand: 118 cm.

INTERPRETATION OF RESULTS—Based on our analyses of the potsherds recovered (Chapter 7), Wain Ware predominates in layer 1, but Sumalo Ware rather than Aiser Ware occurs in layer 2, spits 1 and 2, and Nyapin Ware characterizes layer 2, spits 3–5, as well as layer 3, spit 1. Therefore, it is apparent that the deposition of sand in this location has not been straightforward. Either there was no accumulation of sand here at a time when Aiser Ware was popular on Tumleo, or,

FIG. 6.10. Human mandible, potsherds, and other midden material during excavation of square A, layer C.

perhaps more likely, later erosion has stripped away the sand that had built up then. Similarly, since there was no discernible stratigraphic break between layer 2, spit 2, and layer 2, spit 3, corresponding to the evident chronological break between Nyapin Ware and Sumalo Ware (which may have been several centuries in duration; see Chapter 14), it would again seem probable that the geomorphologic history of this specific locale has been marked by both deposition and erosion—which would conceivably explain why the stratigraphic column here was shallower than in test pit 1.

TEST PIT 3—The southwestern corner of this 1 × 1-m square was 10 m south and 29° southeast of east from the northwestern corner of test pit 2 (Fig. 6.14):

Layer 1, spits 1 and 2: Very dark brown humic sandy loam, stony (spit 2); pottery, shells, bone, chert, and weathered (rounded) pumice stone.

Layer 2, spits 1–5: Stony light grayish/brown sandy loam: pottery, bones, stone, pumice stone, obsidian, and shells.

Layer 3, spits 1–4: Light yellow beach sand; pottery, bone, shells, and pumice pebbles; maximum depth reached in yellow/white sand: 113 cm.

INTERPRETATION OF RESULTS—Once again, based on the sherds recovered (Chapter 7), Wain Ware characterizes layer 1. However, all the underlying layers are evidently characterized solely by Aiser Ware despite the fact that the depth of the stratigraphic column is comparable to that seen in test pit 2. Furthermore, unlike both test pit 1 and test pit 2, layer 2 in test pit 3 was stony enough that it was difficult to excavate. Clearly but not surprisingly, given that sand is the principal component of all three stratigraphic columns, generalizing about the depositional history of these locales must be done with close attention to the nuances of variation in the substantive details of stratification. From this perspective, it would be a mistake to assume that the cultural materials in layer 2 here were in primary position. The stony character of this stratum suggests that high-energy (i.e., storm-related) redeposition of these materials has occurred. This likelihood is supported by the materials found in the underlying layer 3, which are generally quite weathered—suggesting that they were subject to frequent beachfront wave action.

Nonceramic Archaeological Finds

A small number of flaked and ground stone and shell tools and fragments of tools were recovered during the excavations (Figs. 6.16–6.19). Most are adzes or fragments of adzes, although one may be a fragment of a sago pounder (Fig. 6.16g), and others are of uncertain function (Figs. 6.16e, 6.18c, and 6.19a). The most definitive ground stone find is a fragment of a round lenticular stone mace head (Fig. 6.17a), a

Table 6.4. Stratigraphic distribution of potsherds at NGRP 23, St. Martin's. Decorated sherds account for only 2.5% of the total found.

Square	Subsquare	Layer	Total sherds	Sumalo	Punctate	Everted rim	Neck collar	Carination
		Subsurface probe	30				1	
		Surface, east slope	149	2		5	14	1
		Surface, west slope	28	1				
		Surface, north slope	29				6	
A		A	5				1	
A		B	224	8	1	4		1
A		C	258	5		1	8	1
A	A3	C1	37	3		1	1	
A	A4	C1	31	4			4	
A	C3	C1	61	3			3	4
A	B3	C1	37			1	5	
A	B4	C1	18				1	
A	D3	C1	9			4		
A		C2	461	17			9	1
A		C2	2					
B		A	5					
B		B	40				3	
B		C	115	1		1	2	
B		C1	11					
B		C2	42				3	
B		C2	1					
C		B	89	2				
C		C1	54			1	1	
C		C2	16					
C		Surface	1					
D		A	1				1	
D		B	17					
D		C2	4					
E		B	49			1		
E		C	39			1		
Totals			**1,863**	**46**	**1**	**18**	**64**	**8**

form widely distributed in southern New Guinea (e.g., Grottanelli, 1951; cf. Fig. 6.17b). Although attested ethnographically for the Sepik coast (Höltker, 1940–1941), clubs from the Sepik coast are usually made of just palm wood.

Conclusions

The ceramic materials from all the excavations on the mainland at Aitape in 1996 lead to the same observation: apparently the crests of these hills (an uplifted Pliocene/Miocene coral reef formation) were used in ways leading to the observable accumulation of cultural debris when Sumalo Ware (Chapter 14) was available in the Aitape district. In contrast, the excavations carried out on Tumleo Island recovered sufficient evidence in stratigraphic position to reconstruct a fairly definitive ceramic sequence for this part of New Guinea over the past 1,500–2,000 years. Only one of these three excavations, however, produced Nyapin Ware in any abundance at the base of the deposit removed.

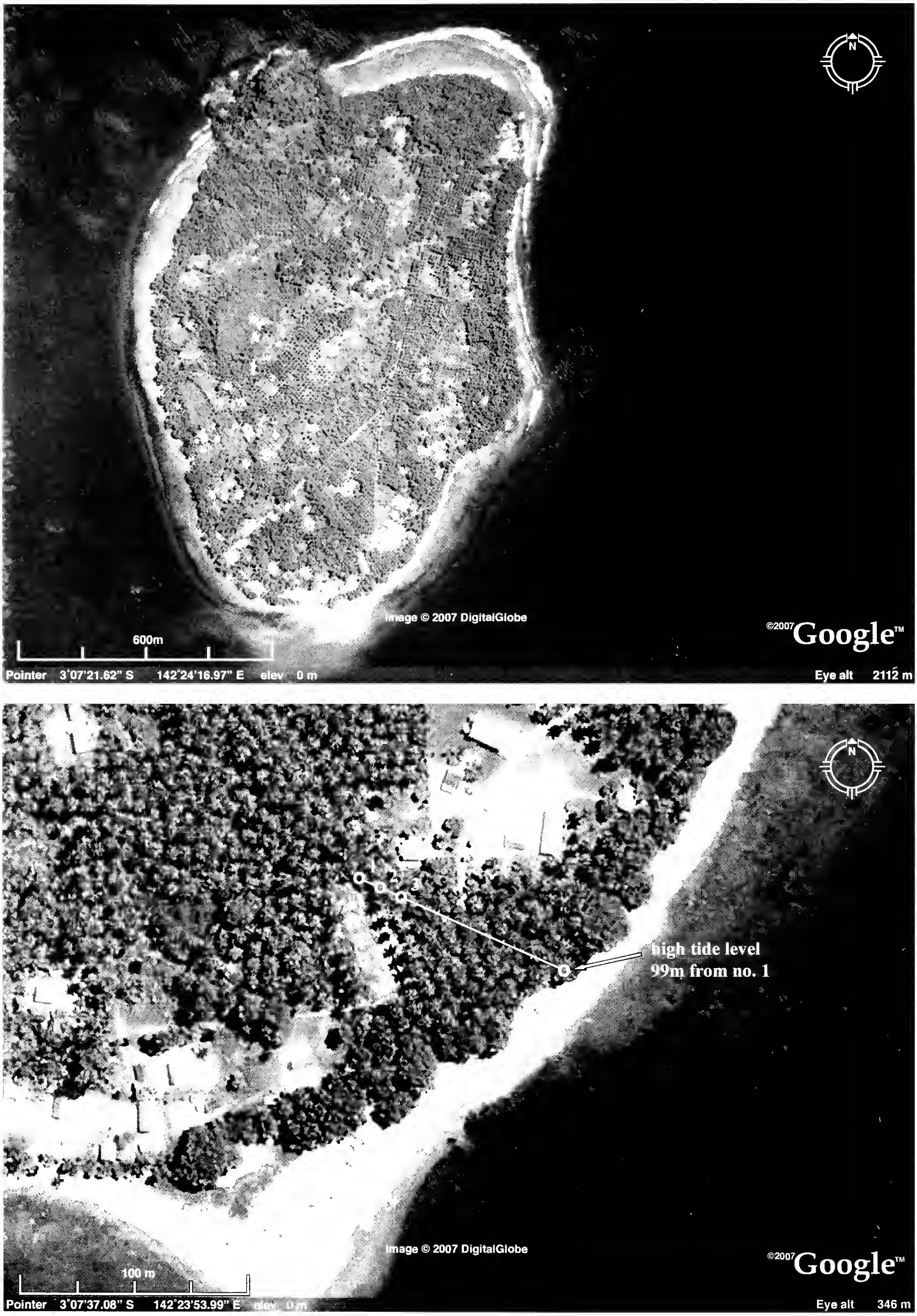

FIG. 6.11. Tumleo Island (top) and the location of NGRP 46, test pits 1–3 (imagery © Google.com).

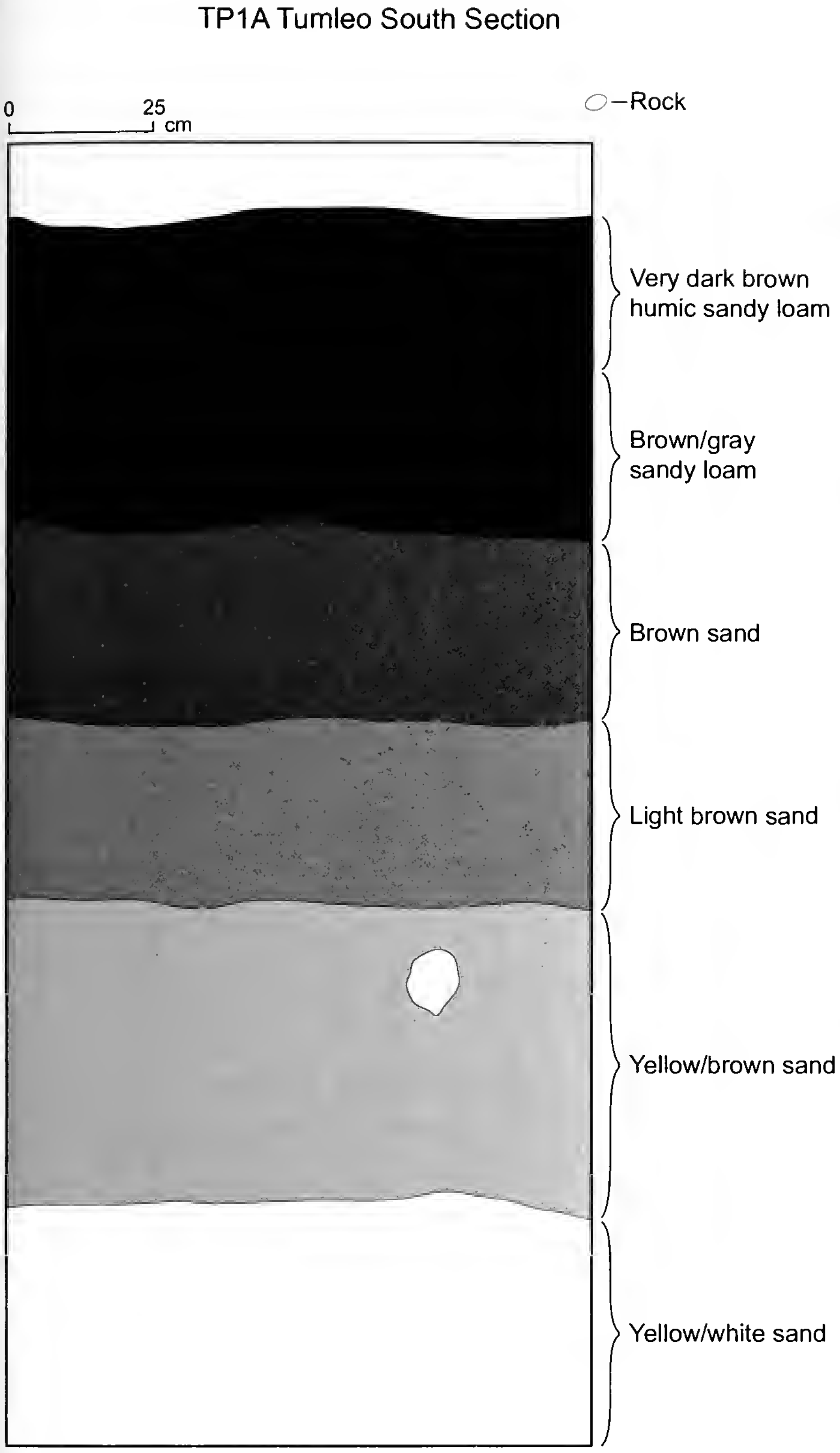

FIG. 6.12. NGRP 46, test pit 1A, south stratigraphic profile.

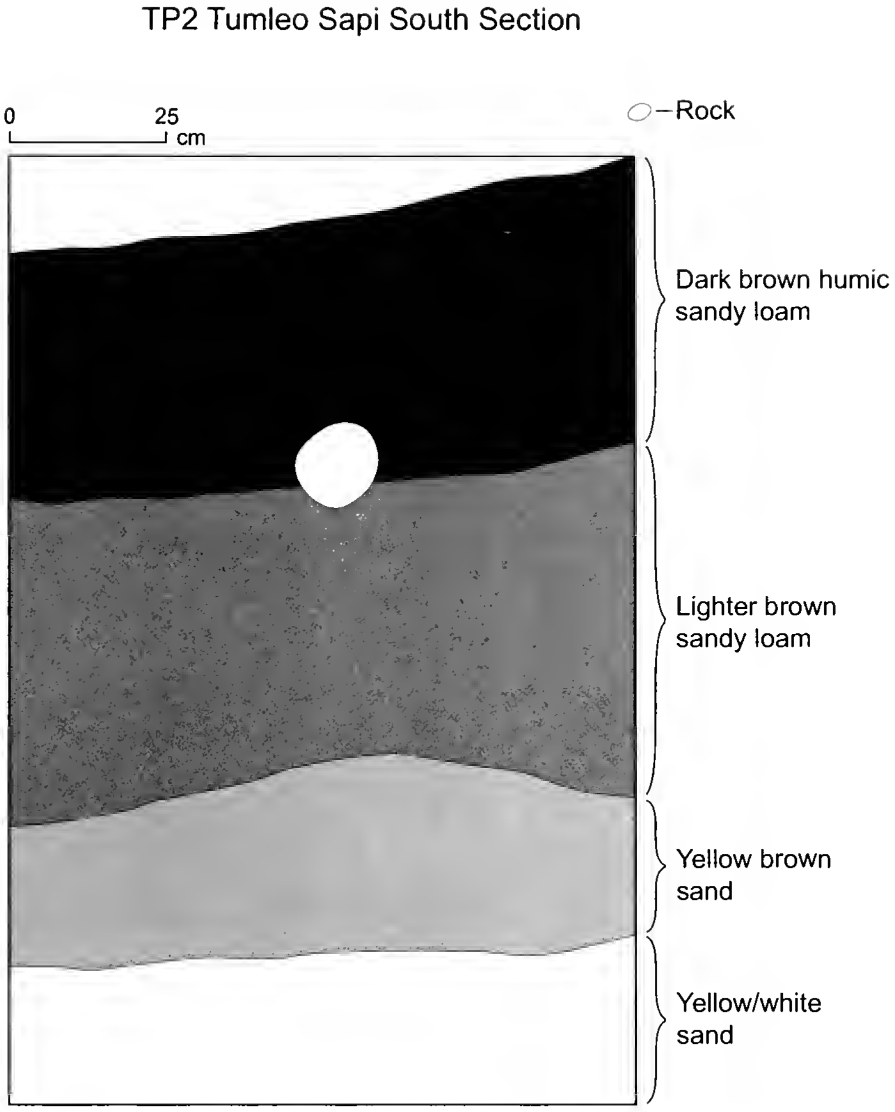

FIG. 6.13. NGRP 46, test pit 2, south stratigraphic profile.

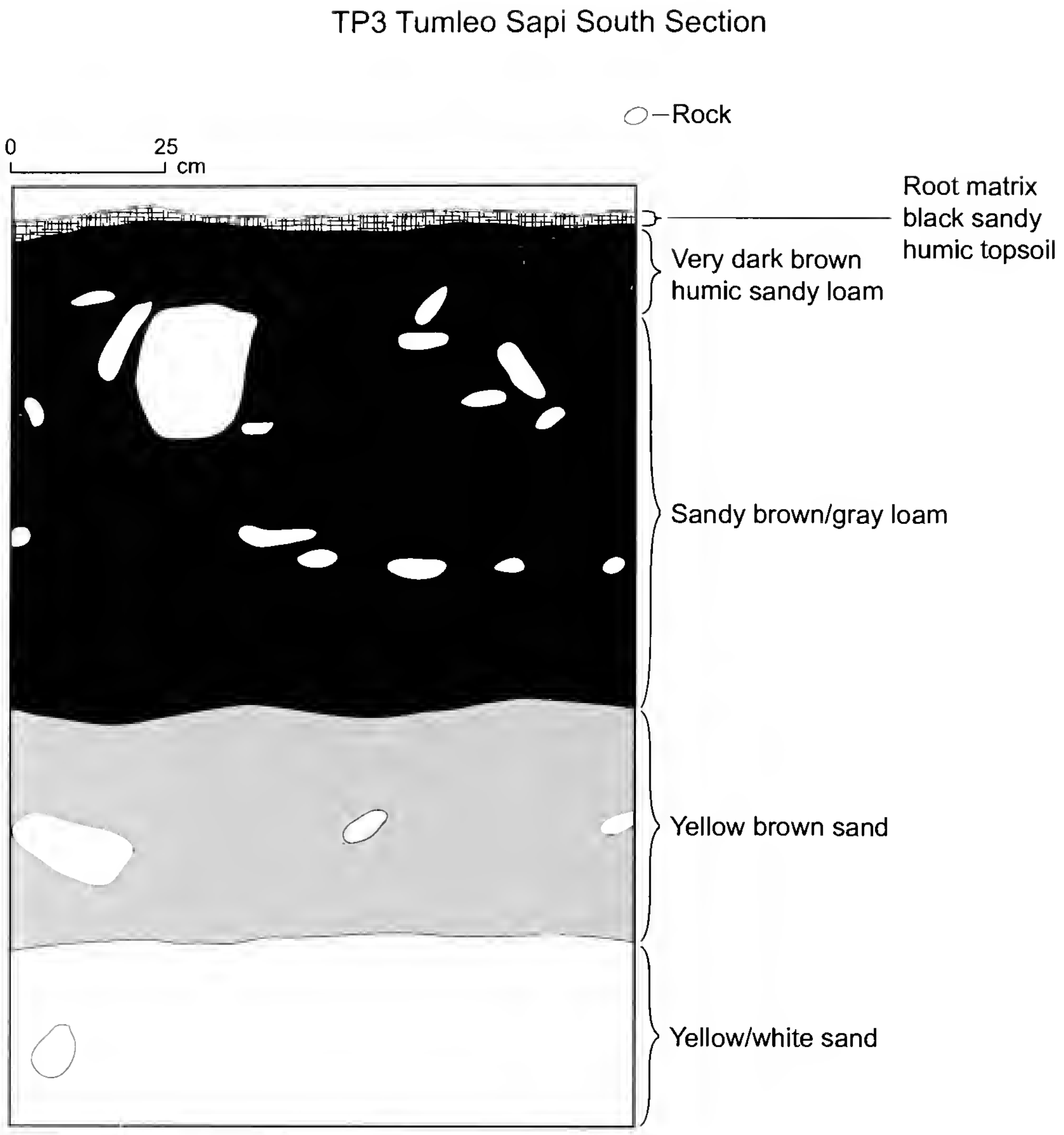

FIG. 6.14. NGRP 46, test pit 3, south stratigraphic profile.

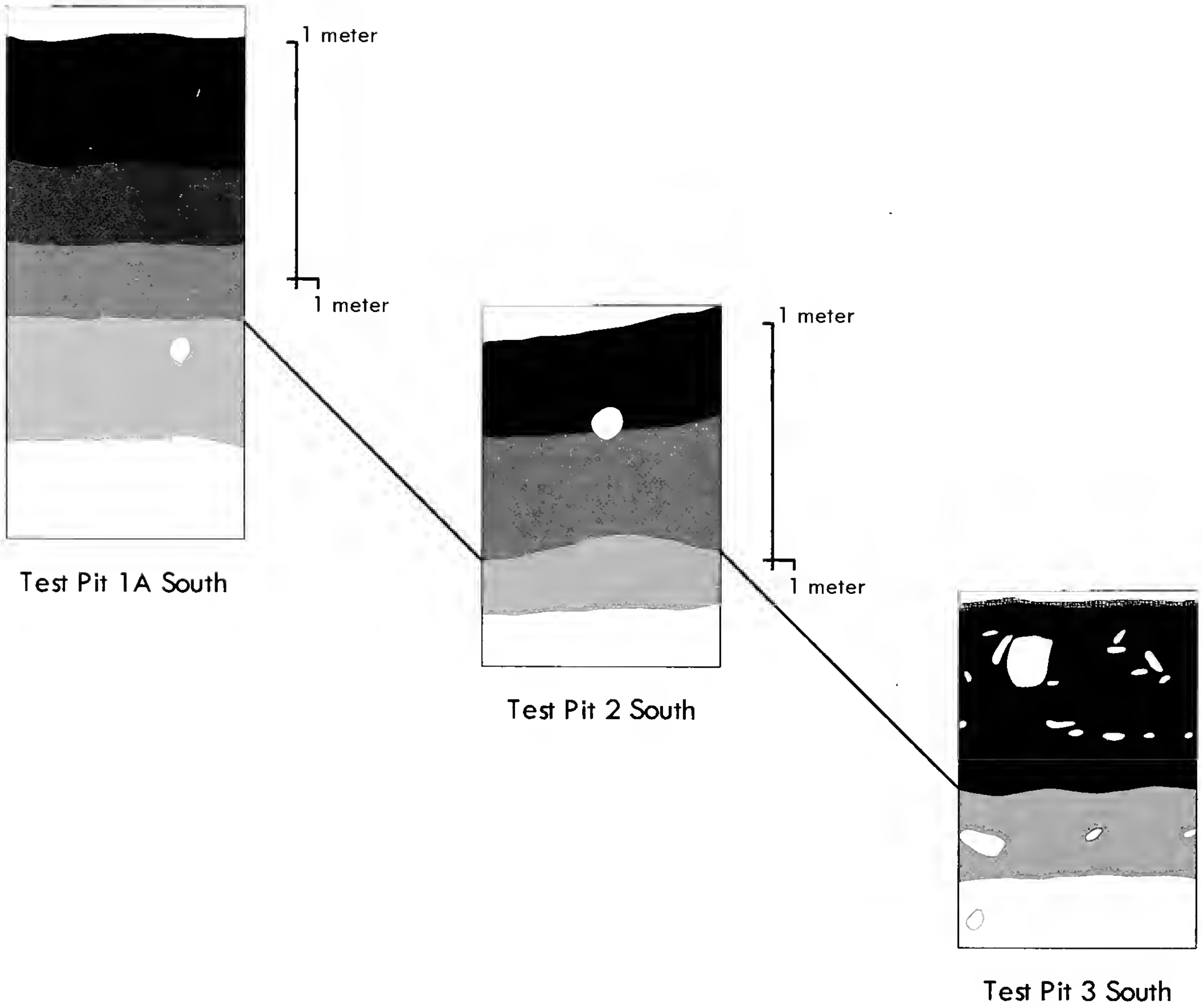

FIG. 6.15. Summary of the test pit stratigraphy at NGRP 46.

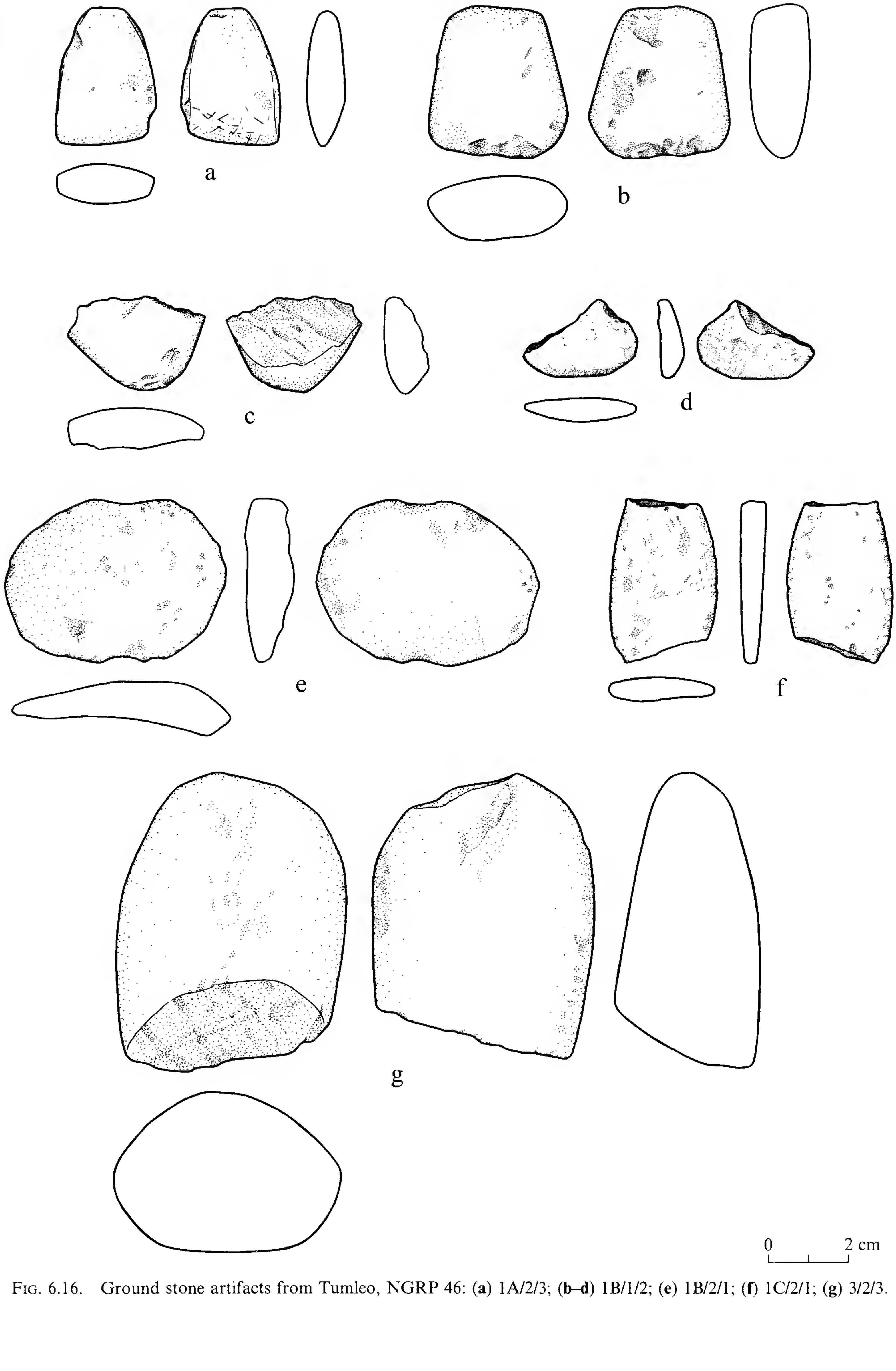

FIG. 6.16. Ground stone artifacts from Tumleo, NGRP 46: **(a)** 1A/2/3; **(b–d)** 1B/1/2; **(e)** 1B/2/1; **(f)** 1C/2/1; **(g)** 3/2/3.

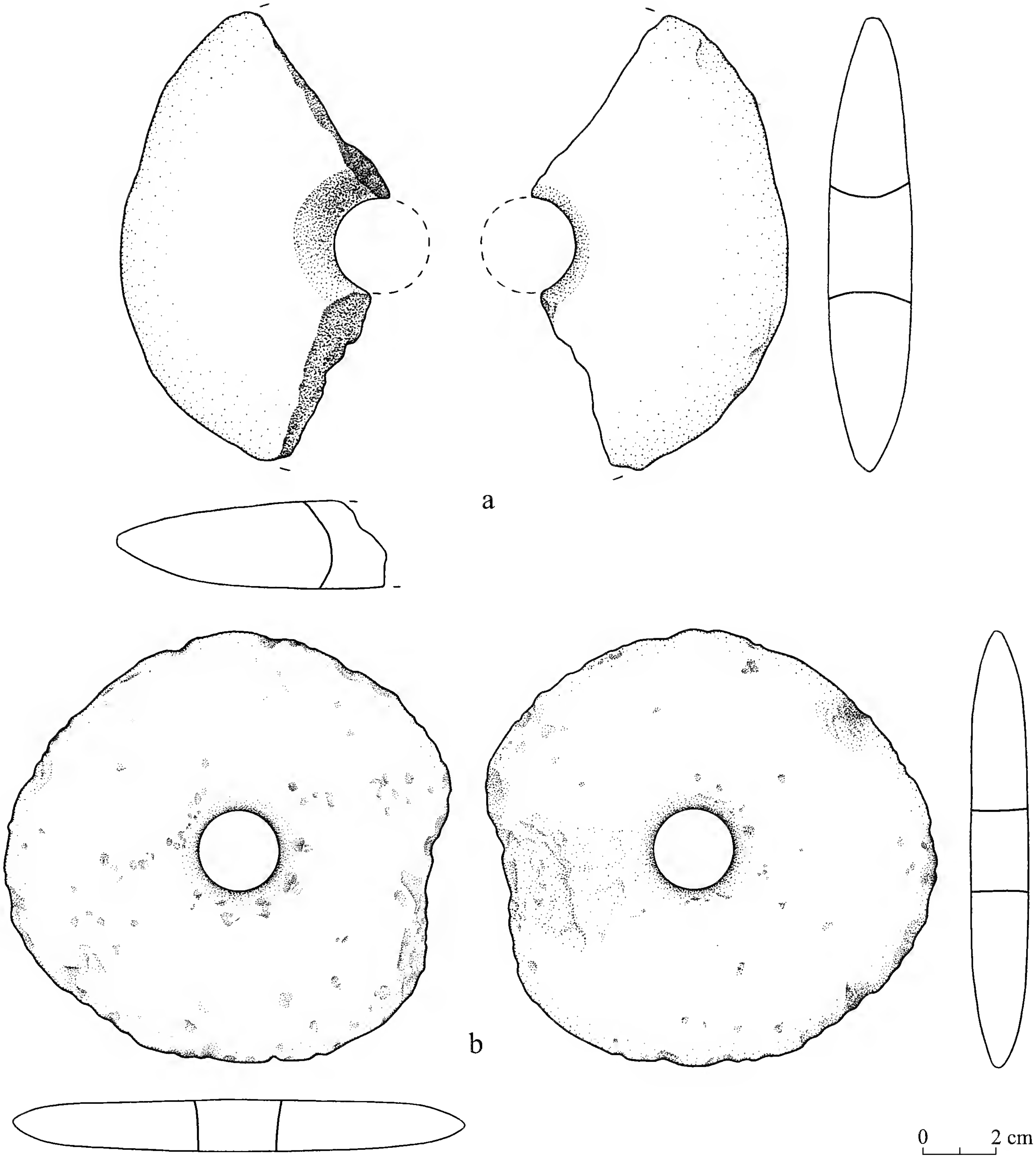

FIG. 6.17. Fragment of a round lenticular mace head (NGRP 46 1A/2/1) and complete ethnographic example (FMNH no. 145968 from Adolfhafen [Morobe], Papua New Guinea, Capt. H. Voogdt Collection).

FIG. 6.18. Ground stone artifacts: (**a**) NGRP 3; (**b**) NGRP 9; (**c**) NGRP 16 C3/B; (**d**) NGRP 16 C3/C; (**e**) NGRP 46 1B/2/1.

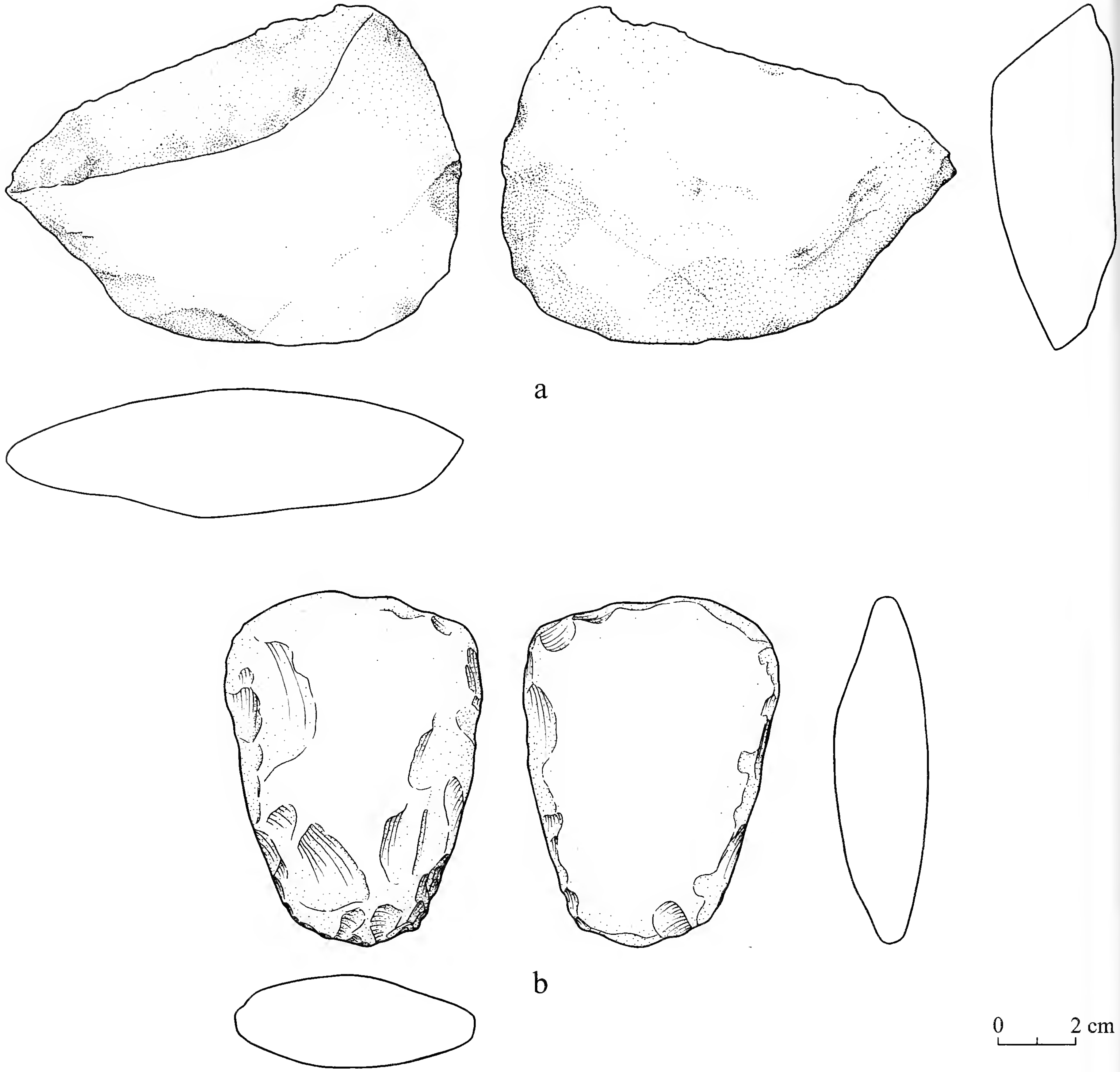

Fig. 6.19. Ground and flaked stone artifacts from Tumleo: (**a**) NGRP 46 A2/1/1; (**b**) Sapi Village.

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Chapter 7: Prehistoric Pottery Wares in the Aitape Area

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Abstract

Using a notational code having three levels of inclusiveness (*attributes*, *attribute themes*, and *motifs*), four stylistically distinct ceramic wares of evident chronological significance can be delineated in the Aitape area: *Nyapin*, *Sumalo*, *Aiser*, and *Wain*. The robustness of this stylistic sequence can be confirmed using two alternative computer-based algorithms: the software package Network 4.5.0.2 developed by Fluxus Technology, Ltd, for estimating all possible shortest and least complex phylogenetic trees in a dataset and the network software packages Ucinet 6.207 and NetDraw 2.083. Based on these analyses, it is reasonable to infer that people in this area of the Sepik coast have been using locally made pottery for at least 1,500–2,000 years belonging to a single, distinct, and stylistically evolving local ceramic tradition.

Introduction

Archaeological excavations were done in 1996 at Aitape for three major reasons. We wanted to do the following:

1. Learn how long people have been making pottery in this part of New Guinea
2. Test the robustness of the ceramic sequence for this area pieced together solely on the basis of undated surface collections by John Terrell while he was in the field in 1993
3. Discover whether his tentatively proposed pottery styles, or wares, in this sequence had been locally made or had come from production centers located elsewhere—a likely enough possibility given the importance of long-distance exchange in this part of the world (Chapter 2; Welsch & Terrell, 1998)

Previous Research

In the late 1980s, Pamela Swadling and Baiva Ivuyo from the National Museum in Port Moresby found potsherds on the hills around Aitape, as Rob Welsch and Terrell later did during their first reconnaissance work in the area in 1990 (Welsch & Terrell, 1991). These surface finds were usually small and eroded.

In 1993–1994, we discovered that the decorative characteristics of most of the pottery sherds we were finding on the small islands offshore near Aitape were rarely seen in the surface collections being made around the mainland town of Aitape. Instead, most of the sherds picked up there were from small round-bottomed pots having thin body walls (~0.3–0.6 cm) and little in the way of obvious surface decoration. Additionally, the pot rims were almost invariably simple and unnotched. In spite of their generally eroded condition, it was often possible to detect nonetheless that in many instances the vessels had been red slipped during their production prior to firing.

When present, surface decoration on the Aitape sherds was limited mostly to small, seemingly indecipherable impressions that we at first suspected might have been made with potter's paddles that had been grooved or decoratively carved in some fashion. Closer study revealed, however, that the obscure designs sometimes present had been done as a finishing touch during pottery production by scoring the still malleable exterior vessel surface with some type of toothed or comblike instrument, not with a carved or grooved potter's paddle (Fig. 7.6).

In 1993, we named this red-slipped and largely undecorated style of pottery *Sumalo Ware* after a collecting locality at the foot of Sumalo Hill near the mouth of the Raihu River on the east side of the town of Aitape (Chapter 5). This was where Welsch and students from the University of Papua New Guinea found the first substantial samples of this ware in the surface collections they made there.

When working once more at Aitape in 1996, Glenn Summerhayes and Terrell noted certain stylistic similarities between the Sumalo Ware sherds that they were recovering at Aitape in both surface and excavated collections and Lapita Ware sherds from elsewhere in the southwestern Pacific (Terrell & Schechter, 2009). They adopted as a working premise the hypothesis that Sumalo might be older and ancestral to Lapita (Terrell & Welsch, 1997). This hypothesis was wrong. Based on subsequent laboratory analyses of surface and excavated collections from 1993–1994 and 1996, as well as on radiocarbon age estimations suggesting that Sumalo Ware dates to ~AD 650–800 (Chapter 14), the more

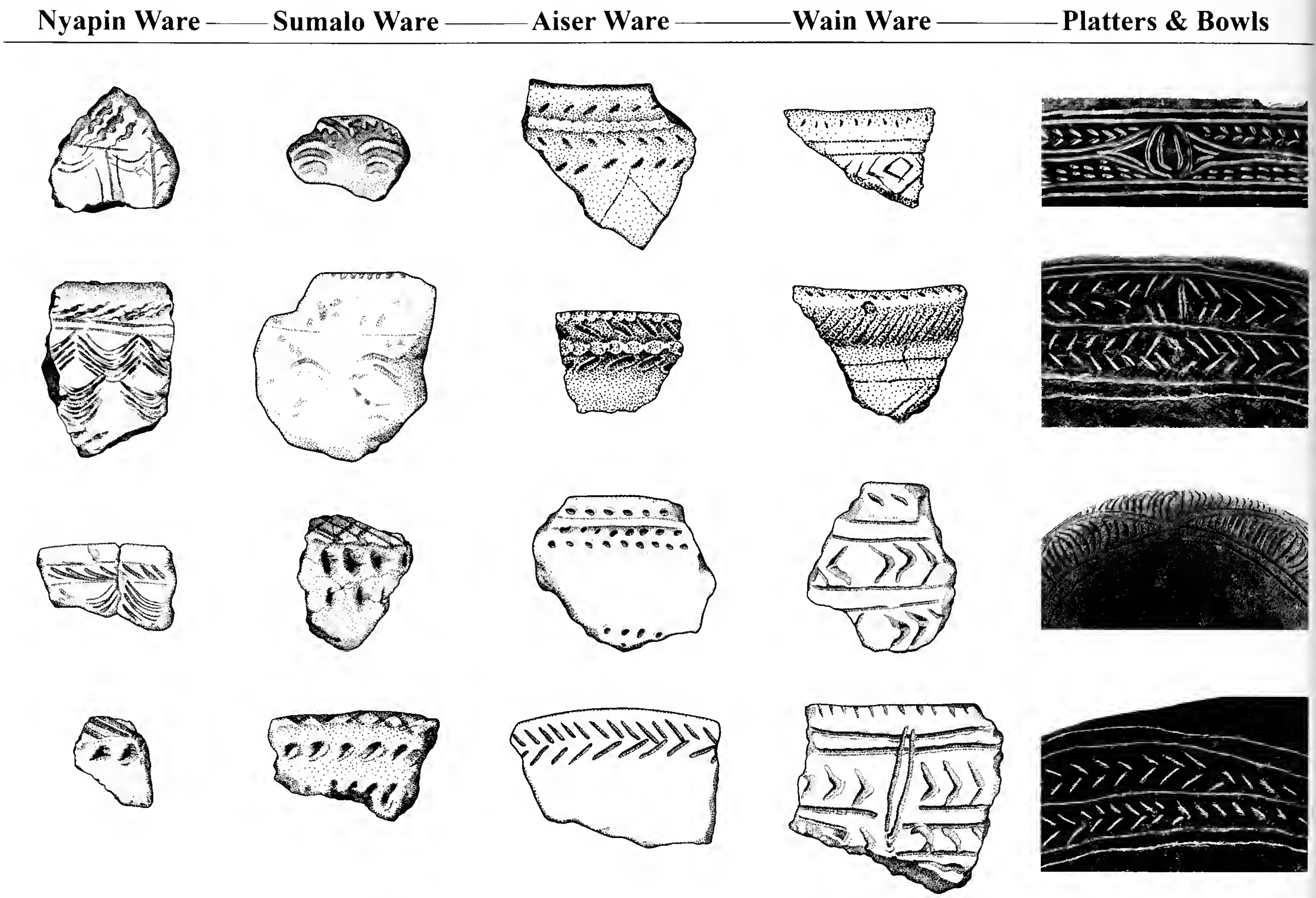

FIG. 7.1. Synopsis of the Aitape ware sequence.

probable hypothesis is that pottery use and production in the Aitape district began around 1,500–2,000 years ago with *Nyapin Ware* (below)—which we now know to be both stylistically and stratigraphically older than Sumalo Ware.

Materials and Methods

Hyman Marx, late curator of amphibians at the Field Museum, liked to repeat the words of advice on how to succeed at the fine art of doing scientific fieldwork that he had been given years earlier by one of his predecessors in the Department of Zoology: "Never go anywhere for the first time." Pioneering archaeology in a new part of the world may sound exciting, but there is an obvious drawback. Pioneering means not knowing what you are going to find.

After several years of weekly laboratory work, we have been able to piece together a stratigraphic ceramic sequence for the Aitape district using the materials obtained there in the field in 1993–1994 and 1996, but we had to do so entirely from scratch. While historic and modern pottery making on Tumleo Island (Chapter 8) had been well reported before we began our laboratory studies (Erdweg, 1902; May & Tuckson, 1982), nothing had been published about prehistoric pottery in this part of New Guinea, although we did know that a single Lapita potsherd had evidently been found somewhere around Aitape or perhaps on one of the nearby offshore islands (nobody today knows for sure) during World War II (Swadling, 1979, 1990; Swadling et al., 1989). Therefore, we had to not only start from scratch, but we also had to build a stratigraphic sequence for this area sherd by sherd.

Coding

Starting in 2002, we worked together one to two days a week in the A. B. Lewis Laboratory at Field Museum systematically studying all the decorated pottery sherds found in the Aitape area in 1996 (Table 7.1). We did so three successive times, each time gaining a more confident sense of the variability present (Fig. 7.3). Our first run through this archaeological material led to a provisional descriptive code for recording what we were seeing. This coding was then refined during our second and third assays of the same material (Table 7.2).

The notation listed in Table 7.2 has three levels of inclusiveness: *attributes*, *attribute themes*, and *motifs*. As just noted, this coding is heuristic. The attributes, themes, and motifs included reflect the variability we observed (Appendix 7.1), and this coding is not intended to be universally applicable, or paradigmatic (Dunnell, 1971). Our definitions of the levels of inclusiveness are as follows:

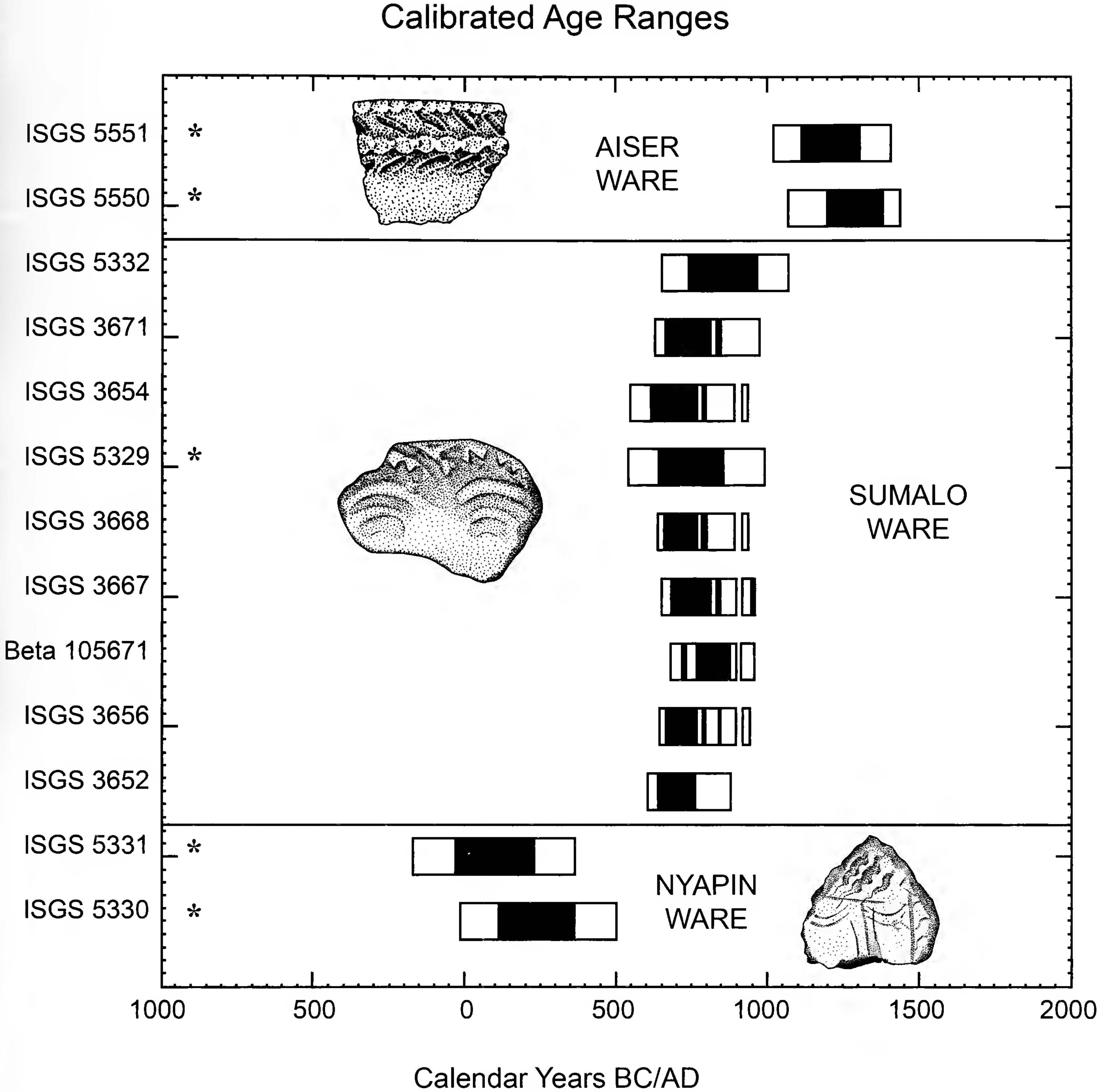

FIG. 7.2. Radiocarbon determinations for the Aitape district with their ceramic associations. Laboratory numbers marked with [*] are shell; a local marine ΔR of 1,005 ± 80 can be estimated for this location (Chapter 14).

TABLE 7.1. Principal materials examined; NGRP 16 and NGRP 23 are shallow, largely single-component Sumalo Ware sites on the mainland at Aitape (Chapter 5); the others are multicomponent (stratified) excavation units at NGRP 46 on Tumleo Island (Chapter 6).

Excavation area	Total no. of sherds	No. decorated	%
NGRP 46, #1	12,920	1,708	13.2
NGRP 46, #2	3,832	639	16.7
NGRP 46, #3	1,609	409	25.4
NGRP 16	960	27	2.8
NGRP 23	1,863	54	2.9

Attribute—An observable property or quality, such as "notched lip," "red film," and "herringbone punctations"

Attribute theme—A combination, or association, of attributes, such as "flat lip with punctations on lip surface," and "appliqué band or bands with one or more bordering rows of diagonal punctations"

Motif—A consistent way of placing an attribute theme on a ceramic vessel (Fig. 7.4) creating a distinctive visual impression, such as "linear or curvilinear hanging incisions on interior rim surface below notched lip," and "triangular lip with crosshatched incisions on lip surface and interior rows of punctations below the lip edge"

FIG. 7.3. Esther Schechter at work in the A. B. Lewis Laboratory at the Field Museum of Natural History.

Prehistoric Ceramic Wares

Prehistoric pottery in the Aitape area was rich in its variable decorative characteristics. However, many of the more conspicuous ceramic traits can be used to delineate four stylistically distinct wares of evident chronological significance: *Nyapin*, *Sumalo*, *Aiser*, and *Wain* (Figs. 7.1 and 7.2). The size of each of the stratigraphic excavation units of material available for study was usually small (e.g., Table 7.3). Therefore, while the following descriptions of these wares should prove robust enough to serve as a starting foundation for future archaeological research in the area, these ware descriptions should be seen as provisional.

Nyapin Ware

The exterior surface as well as some or all of the interior surface of Nyapin bowls and platters was usually covered with a pleasing red clay slip as a final step in their production prior to firing. Carinated bowls (B-12) are in evidence. Some vessels were decorated using fine-line incising, fine-line linear or wavy scoring (Appendix 7.1, D-22 and D-23), stick punctations, or shell-edge impressions (Fig. 7.5). The design field on the outer surface was apparently seen by potters as subdivided into contiguous bands or zones of decoration (Fig. 7.4). While the evidence available is limited, it seems likely that sometimes potters marked these zones with finely incised lines (Fig. 7.5a, b, g). Based on the available evidence, fairly naturalistic "eyes" (M-20, M-21) were applied to Nyapin bowls (Fig. 7.5b) as well as to platters (Fig. 7.5g) with triangular vessel lips (L-41); additionally, what may be more abstract representations of eyes formed by deep punctations (Fig. 7.5h) are found on some platter rim sherds (B-11). In both instances, the "eyes" are complemented by an upper decorative zone of diagonal shell-edge impressions or short incisions (M-23).

Sumalo Ware

Most (if not all) Sumalo Ware vessels appear to have been washed with red clay slip prior to firing. Everted vessel rims may have a striking "rolled" (concave) profile in cross section (Appendix 7.1, B-14). A very small number (<3%) were also decorated by scoring or impressing at least part of the exterior surface with what may have been the flat or slightly cupped end of a sticklike tool, or with a comblike "dentate" tool having several broad teeth (D-21)—a tool that may have been homologous to Lapita dentate tools (Summerhayes, 2007). The resulting visual impression is often that of wavy or random scoring and possibly also overscoring. Naturalistic "eyes" done in broader strokes (M-22) than on Nyapin vessels occur on bowls (Fig. 7.6a–e); the eyes on platters were evidently done only as punctations (Fig. 7.6f–i). Once again, there is some evidence showing that this eye motif is usually complemented by an upper decorative zone of impressions, punctations, or incisions (Fig. 7.6a–i). Carinated bowls (B-12) and shallow ceramic bowls or platters (B-11) also occur (Fig. 7.7).

Aiser Ware

As were Nyapin and Sumalo vessels, Aiser Ware bowls were usually washed with a red clay slip prior to firing. Many Aiser vessels were decorated using one or more of several distinctive techniques, including diagonally scored lines and punctations (Appendix 7.1, D-41 and D-42), appliqué nubbins (D-53), appliqué bands, and punctate-appliqué bands (D-52). Incised hanging lines were frequently used on lower areas of the vessels (Figs. 7.8 and 7.9). The interior (or upper) surfaces of everted rim vessels are commonly notched and decorated in a number of ways with incised designs (M-11–M-14). While the evidence is not definitive, there is a possibility that some Aiser Ware vessels had small lugs (L-51) on the outer vessel lip (Fig. 7.9k).

On present evidence, shallow ceramic bowls or platters were not made by potters when Aiser Ware was in fashion, and it may have been at this time in the Aitape ceramic sequence that crafting these items in wood rather than out of clay became popular as an alternative mode of production (Fig. 7.1; Chapter 9). If this is what happened, this shift in preference from ceramics to wood may explain why design motifs previously used around the inner edges (rims) of ceramic platters were used to decorate the inner (i.e., upper) rim surface of Aiser Ware everted rim pots (Fig. 7.10).

Wain Ware

The convention of washing the surface of ceramic vessels with red clay slip prior to firing had evidently been abandoned by potters making Wain pots and bowls. They did, however, continue to embellish their vessels with punctations, linear incisions, punctate or incised herringbone designs (Appendix 7.1, D-32 and D-43), rare small appliqué nubbins, and the like (Fig. 7.11). The design field was commonly subdivided into separate zones set off from one another by double incised lines (D-34 and T-62). Vessel rims were often thick and notably flat (L-21); the lip was often marked with punctations either on or below the lip edge (T-11 and T-21–T-22; Fig. 7.11a, b, d–j).

Aitape Ceramic Sequence

As Table 7.4 shows, the distribution of design characteristics across these four proposed prehistoric wares seems recurrent enough to infer that all four wares must be

TABLE 7.2. Coding used for recording ceramic traits.

Body (shape) attributes	
B-00	bowl sherd
B-11	platter sherd
B-12	carinated vessel sherd
B-13	everted rim sherd
B-14	rolled everted rim sherd
Decorative attributes	
D-00	plain (undecorated)
D-11	red slip
D-21	broad-toothed scoring and punctation
D-22	fine-line scoring
D-23	fine-line wavy scoring
D-31	hanging incised or appliqué lines
D-32	herringbone incised
D-33	rickrack gouged
D-34	incised zoning
D-41	row of diagonal punctations
D-42	alternating rows of diagonal punctations
D-43	herringbones punctate
D-51	appliqué bands
D-52	punctate appliqué bands
D-53	nubbins or vertical appliqué bands
Lip attributes	
L-00	lip sherd
L-11	notched lip
L-21	flat lip
L-31	beveled lip
L-41	triangular lip
L-51	lug(s) at lip edge
Decorative themes (a combination of two or more coded attributes)	
T-11	punctations below lip
T-21	flat lip with punctations on lip surface
T-22	flat lip with notches on lip edge
T-23	flat lip with appliqué or incised decorations on lip surface
T-31	notched lip with diagonal lines or punctations below lip edge
T-41	"plant"—herringbone incisions separated by an incised line
T-61	two or more incised lines with one or more lateral row(s) of diagonal punctations or incisions
T-62	incised lines bordering herringbone punctations
T-71	appliqué punctate bands with one or more row(s) of diagonal incisions or punctations
T-81	"bull's-eye" (multiple linear or curvilinear concentric lines)
T-82	"bull's-eye" with guide marks
Decorative motifs—a consistent way of using attributes and themes to create a combined visual impression	
M-11	notched everted rim with diagonal lines or punctations
M-12	notched everted rim with linear or curvilinear hanging incised lines
M-13	notched everted rim with linear or curvilinear hanging incised lines and vertical or diagonal incised lines below lip edge
M-14	notched everted rim with incised "plant" design on interior (upper) surface
M-20	zoned fine-line incised "face"
M-21	zoned fine-line scored "face"
M-22	broad-tooth scored and impressed "face"
M-23	zoned punctate "eyes" below crosshatch incised and triangular lip
M-24	zoned punctate "eyes" with appliqué band
M-25	zoned diagonal punctate "eyes" with punctate appliqué band
M-26	elaborated zoned diagonal punctate "eyes" with punctate appliqué band
M-31	zoned herringbone designs below flat lip
M-32	zoned herringbone and "bull's-eye" designs below flat lip

historically related to one another. On present evidence, for example, Aiser Ware could be described as a somewhat later and more ornate version or variety of Sumalo Ware. To evaluate this evidence for historical continuity from ware to ware as thoroughly as possible, we turned to several software tools that have recently become available for such work with considerable success.

Figure 7.12 displays the stratigraphic information from the excavations at NGRP 46 on Tumleo Island (Table 7.3) as an unrooted phylogenetic tree. This graph was constructed using the software package Network 4.5.0.2 developed by Fluxus Technology, Ltd, for estimating all possible shortest and least complex phylogenetic trees (all *maximum parsimony* trees) in a dataset. We transformed the information in Table 7.3 into binary format (a binary character has only the two states 0 or 1) as required by the software, and used this program with the median-joining network algorithm of Bandelt et al. (1999), an algorithm that integrates minimum spanning trees into a single network.

The resulting data array (Fig. 7.12) has no obvious phylogenetic (i.e., historical) interpretation and would seem to be suggesting that the more strikingly decorated Nyapin, Aiser, and Wain wares are separate variants branching off from the less ornate Sumalo Ware, which is located by the program (with one exception) at the center of the mapped array. It should be noted that it seems likely that the specific branching patterns of the constituent spanning trees may reflect variation in the sample size of nodes, and hence caution should be observed when trying to interpret them.

What does seem evident from this phylogenetic analysis, however, is that our laboratory assignment of these excavation units (here expressed as nodes) to the proposed four wares was not misleading or capricious. With only a few apparent exceptions, the units (nodes) are clustered together in this tree network as we had assigned them stylistically. Of the four exceptions, nodes 1C/1/2 and 2/2/1 (see Appendix 7.1) are excavation units positioned stratigraphically between units designated as Aiser and Wain, respectively; that is, they may not be exceptions to the clustering of nodes by ware types shown in the figure. Only nodes 3/3/3 and 3/3/4 are seemingly more clearly anomalous. Their stratigraphic positioning near the bottom of test pit 3 below units that can be assigned with confidence to Aiser Ware seems inconsistent with their placement near nodes assigned to Wain Ware. This could be taken as possible further evidence that the Aiser component in this test pit has been impacted by high-energy (storm-related) redeposition (Chapter 6).

While an often useful way to sort out and illustrate information on how things may be interrelated in a meaningful way, estimating shortest and least complex phylogenetic trees—which, to repeat, is what we did when constructing Figure 7.12—for the sake of parsimony or convenience may hide much of the information available about the relationships being analyzed. Therefore, we also elected to use the network software packages Ucinet 6.207 and NetDraw 2.083 (Borgatti, 2002; Borgatti et al., 2002) to explore the historical implications of the information given in Table 7.3 using a substantially different analytical approach (for discussion of social network analysis, see Terrell 2010a, 2010b).

Unlike phylogenetic algorithms that coalesce multiple and varying relationships among nodes into singular branching points (or, as in Figure 7.12, into multiple possible branching points when this cannot be done by the program used), network methods (Lipo, 2006) are able to show which nodes (here, excavation units) are similar to other nodes in discernible

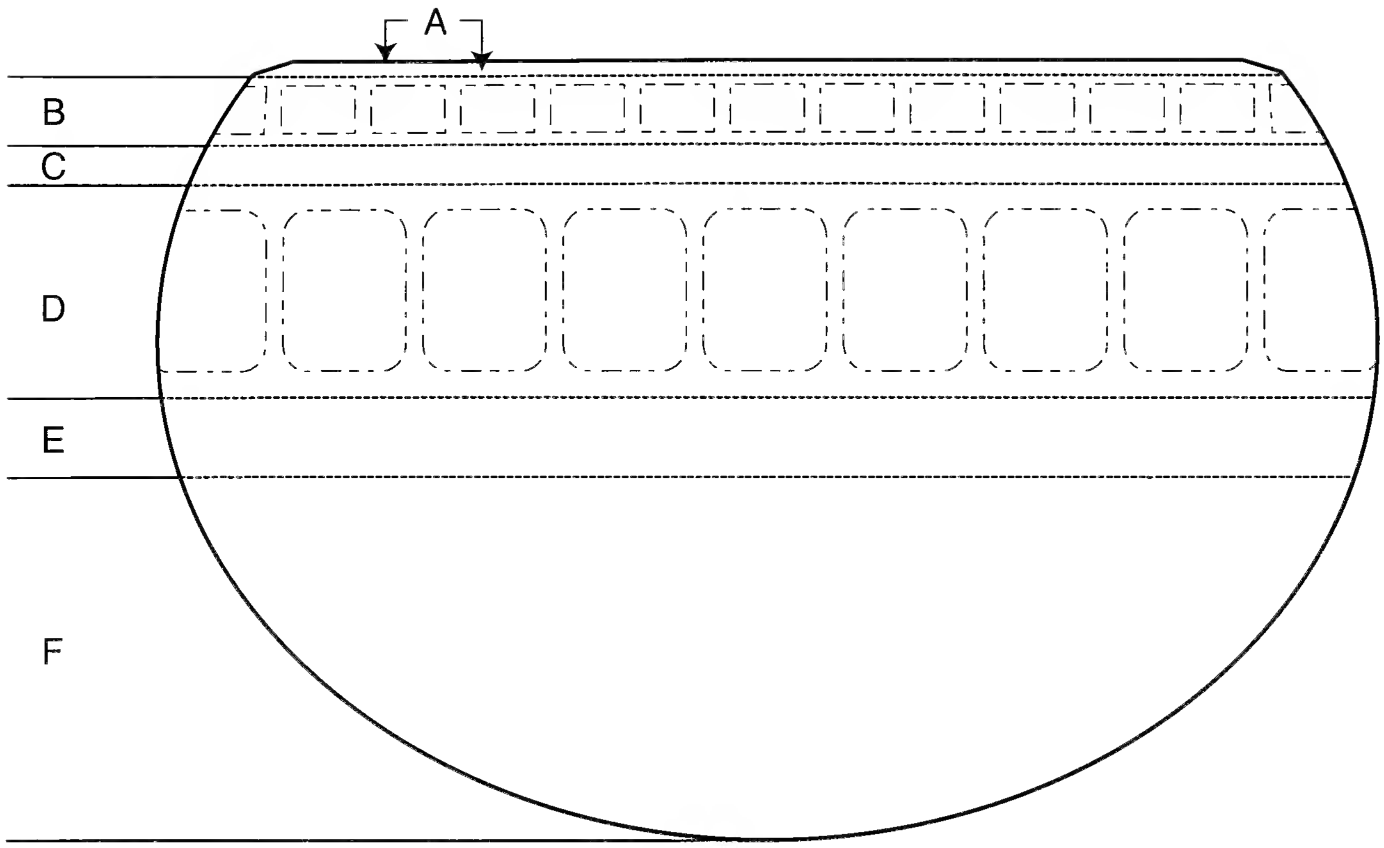

FIG. 7.4. Idealized bowl showing the decorative zones used in the coding devised for prehistoric pottery in the Aitape area.

TABLE 7.3. Stratigraphic materials studied from the test excavations in 1996 on Tumleo Island (NGRP 46, test pits 1–3).

	B-11	B-12	B-13	B-14	D-21	D-22	D-23	D-31	D-32	D-33	D-34	D-41	D-42	D-43	D-51	D-52	D-53	L-11	L-21	L-31	L-41
1/A–C/ surface	0	0	0	0	0	0	0	1	1	3	9	3	1	4	4	2	0	0	6	2	0
1/A/1/1	0	0	0	0	1	0	0	1	6	0	4	1	0	2	1	1	0	0	5	3	0
1/A/1/2	0	0	4	0	0	0	0	8	2	3	12	1	0	4	3	4	2	0	9	1	0
1/A/2/1	0	0	1	1	9	0	0	4	3	0	5	10	7	2	3	15	4	2	4	0	0
1/A/2/2	4	1	24	4	21	1	1	13	6	0	9	36	29	1	33	35	9	26	2	3	9
1/A/2/3	1	3	6	0	13	0	0	0	0	0	0	4	0	2	3	3	2	2	1	0	3
1/A/3/1	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/A/3/2	1	2	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
1/A/3/3	0	2	0	1	14	0	0	0	0	0	0	1	0	0	1	2	1	1	0	0	0
1/A/4/1	0	1	2	3	10	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1/A/4/2	0	0	0	0	5	1	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0
1/B/1/1	1	0	1	0	1	0	0	4	0	1	3	2	0	2	3	1	1	0	10	0	1
1/B/1/2	0	1	0	0	3	0	0	5	4	0	19	3	1	9	2	3	0	1	12	1	0
1/B/2/1	0	1	7	0	30	0	0	14	1	0	1	31	42	4	14	31	13	14	1	0	0
1/B/2/2	1	1	4	0	24	0	0	5	2	0	0	27	11	0	2	23	10	11	1	2	1
1/C/1/1	0	0	0	0	0	0	0	3	0	0	3	0	1	1	2	1	0	0	2	0	0
1/C/1/2	0	0	1	0	3	0	0	8	4	0	5	1	2	2	2	2	3	1	10	2	0
1/C/2/1	0	0	5	2	35	0	1	11	2	0	0	34	8	2	2	45	11	9	2	1	0
2/1/1	0	0	0	0	0	0	0	1	0	0	1	0	0	2	0	0	0	0	0	0	0
2/1/2	0	0	0	0	0	0	0	1	1	0	2	5	0	3	1	0	0	0	1	1	0
2/2/1	2	2	3	3	33	0	0	1	2	0	0	3	0	1	0	5	1	0	3	1	2
2/2/2	2	1	0	0	5	0	0	0	0	0	0	2	1	0	0	3	0	1	0	0	3
2/2/3	1	2	1	1	21	11	3	0	0	0	2	0	0	0	0	0	0	1	0	1	2
2/2/4	7	6	3	0	8	14	1	0	1	0	0	1	0	0	0	3	3	1	0	0	7
2/2/5	1	1	1	0	2	4	1	0	0	0	1	0	0	0	0	0	0	1	2	0	1
2/3/1	5	0	1	1	1	7	3	0	0	0	0	0	0	0	0	0	0	0	1	0	4
3/1/1	0	1	0	0	0	0	0	1	1	1	3	2	1	1	0	4	1	0	4	0	0
3/1/2	0	0	0	0	1	0	0	0	1	0	0	2	3	0	0	3	0	0	2	0	0
3/2/1	0	0	0	0	0	0	0	4	0	0	0	4	2	0	0	8	1	3	1	0	0
3/2/2	0	0	2	1	0	0	0	3	0	0	0	1	3	1	3	1	2	2	2	0	0
3/2/3	0	0	1	0	1	0	0	1	0	0	0	9	10	0	6	5	6	1	2	0	0
3/2/4	2	0	1	0	6	1	1	2	2	0	1	8	6	0	9	7	2	1	0	1	2
3/2/5	0	0	1	0	3	0	0	0	0	0	2	5	0	0	1	3	3	0	0	0	0
3/3/1	0	0	0	0	1	0	0	5	0	0	0	6	6	0	1	8	2	2	1	0	0
3/3/2	0	1	2	0	5	0	1	1	2	0	0	8	1	0	0	13	1	4	1	0	0
3/3/3	0	0	0	0	1	0	0	0	1	0	1	5	1	0	0	10	0	0	2	0	0
3/3/4	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0
Totals	**29**	**28**	**71**	**17**	**268**	**40**	**12**	**98**	**43**	**8**	**83**	**216**	**136**	**43**	**98**	**243**	**78**	**89**	**87**	**19**	**35**

ways—in this instance, by how strongly these units resemble one another in their ceramic content. Additionally, there are several commonly used computational techniques for placing nodes relative to one another in multidimensional (usually two- or three-dimensional) space such that the distances and directions among nodes may also be interpretable. These techniques include metric and nonmetric dimensional scaling, principal components analysis, spring embedding, and other strategies (Hanneman & Riddle, 2005).

Figure 7.13 graphically conveys Pearson's correlation values among the excavation units at NGRP 46 based on the trait frequencies in Table 7.3 when the edge (i.e., linkage) weight is set at a value of ≥0.417, the minimum threshold at which all the nodes (units) are linked with at least one other node in the dataset. The layout of nodes shown was achieved using spring embedding (Fruchterman & Reingold, 1991), a technique for drawing network graphs that distributes nodes in (here, two-dimensional) space while at the same time keeping associated nodes visually near one another (Golbeck & Mutton, 2005, pp. 173–174).

When Figure 7.13 is compared with Figure 7.12, it is apparent just how much information may be hidden from consideration by using phylogenetic rather than network algorithms on datasets such as the one under consideration. Closer inspection of Figure 7.13 also establishes that network mapping of similarities among the excavation units at NGRP 46 effectively reproduces the sequence of wares we arrived at in the laboratory. Unlike Figure 7.12, which places Sumalo Ware in the center of an unrooted tree, both the sequence and the relative degrees of similarity among the four wares are readily apparent: the nodes we had assigned in the laboratory to Nyapin, Sumalo, Aiser, and Wain wares sort out as such in this computer-generated network graph. Once again, however, as was the case with Figure 7.12, it seems likely that caution should be observed when trying to sort out the relationships of the specific nodes within each of the four network clusters, although the anomalies noted in Figure 7.12 do not reoccur in Figure 7.13, suggesting that they may simply be artifacts of the phylogenetic program used.

Heartened by these results obtained using two different computer-aided approaches to data analysis, we decided to use the composite ceramic information given in Table 7.4 to summarize in a far less complicated manner why we conclude that at least four pottery wares are recognizable in the Aitape ceramic sequence as presently understood, and that all four of these styles of pottery are historically related to one another (Tables 7.5 and 7.6; Fig. 7.14).

Conclusions

We know that there are hazards in trying to draw inferences about human history from the information currently available

Table 7.3. *Extended.*

L-51	T-11	T-21	T-22	T-23	T-31	T-41	T-61	T-62	T-71	T-81	T-82	M-11	M-12	M-13	M-14	M-20	M-21	M-22	M-23	M-24	M-25	M-26	M-31	M-32	Totals
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	38
0	1	1	1	0	0	0	0	1	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	33
0	0	0	3	2	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	61
0	3	3	1	0	0	4	2	1	6	1	3	1	0	1	0	0	0	0	0	0	5	0	1	1	103
2	4	4	0	0	11	8	6	0	39	0	0	21	2	0	1	0	1	1	2	1	29	5	0	0	404
1	3	3	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	56
0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16
0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	10
0	4	2	2	1	0	0	2	2	1	1	4	0	0	0	0	0	0	0	0	0	0	1	1	0	52
0	4	1	3	1	0	0	0	12	2	1	3	0	0	0	0	0	0	1	0	0	2	0	4	1	99
6	13	1	0	0	11	5	13	0	23	0	0	1	0	1	0	0	0	1	0	6	3	3	0	0	291
1	18	1	4	0	2	7	7	0	20	0	0	3	0	1	0	0	0	4	1	1	13	5	0	0	213
0	2	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	18
0	5	2	2	2	1	0	1	2	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	65
3	18	0	2	2	1	11	1	1	29	0	1	0	0	0	2	0	0	4	0	2	10	6	0	1	264
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
0	1	1	0	0	0	0	1	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22
0	3	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	70
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	21
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	2	0	0	0	0	0	52
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	1	0	0	0	0	0	61
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	16
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	27
0	2	2	1	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	30
1	0	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	19
1	1	0	0	0	1	0	2	0	4	0	0	0	3	0	0	0	0	0	0	0	2	3	0	0	40
1	0	0	0	0	1	0	2	0	2	0	0	0	1	1	0	0	0	1	0	2	1	0	0	0	33
0	2	0	0	0	0	1	2	0	7	0	0	1	0	0	0	0	0	1	0	1	3	0	0	0	60
0	1	0	0	0	0	1	7	0	5	0	0	0	0	0	0	0	1	0	0	1	0	4	0	0	72
1	0	0	0	0	0	0	7	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	29
0	0	2	0	0	0	0	2	0	6	0	0	0	0	0	0	0	0	0	0	0	2	6	0	0	50
0	2	1	0	0	3	0	1	0	6	0	0	3	0	0	0	0	0	0	0	0	1	1	0	0	58
0	3	1	1	1	0	1	4	0	4	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	39
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	7
17	**94**	**29**	**20**	**11**	**32**	**40**	**61**	**26**	**163**	**9**	**15**	**31**	**6**	**4**	**3**	**1**	**10**	**18**	**14**	**15**	**74**	**39**	**8**	**3**	**2484**

on ceramic variability and chronology in the Aitape area. This having been said, we think that the objectives of the 1996 archaeological excavations were met. It seems reasonable to infer that people in this part of New Guinea have been using locally made pottery for at least 1,500–2,000 years (Chapter 14). The preliminary ceramic sequence developed by Terrell in 1993 using only surface collections has proved to be surprisingly robust, and his preliminary sequence can now be extended farther back in time to include Nyapin Ware. Furthermore, on the basis of both formal (stylistic) analysis (this chapter) and also provenience studies of ceramic samples (Chapter 13) using laser ablation inductively coupled plasma mass spectrometry, the Aitape sequence can be reconstructed as a distinct evolving local ceramic tradition.

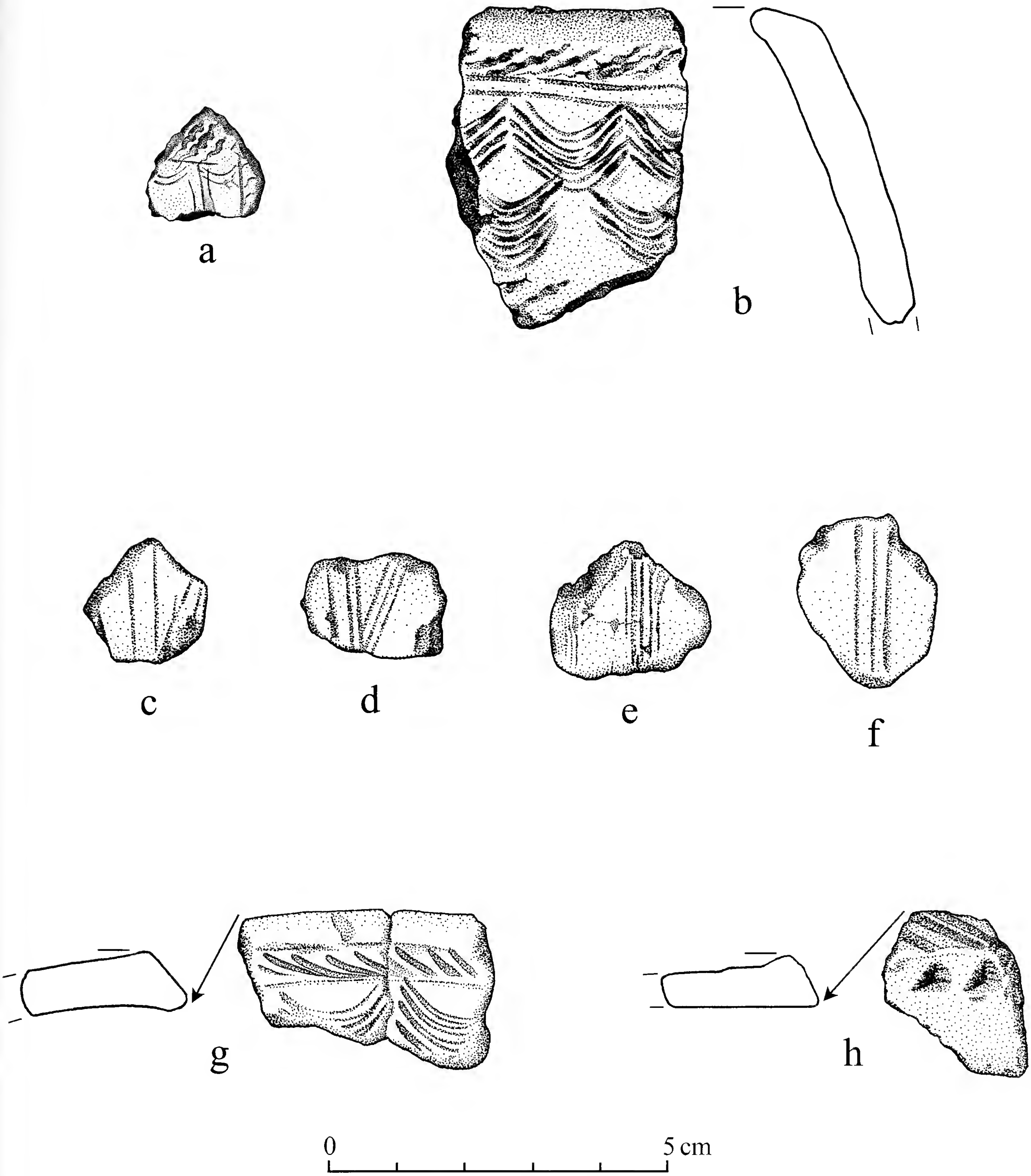

FIG. 7.5. Nyapin Ware decorated sherds from NGPR 46: (**a**) 2/2/4; (**b**) 2/2/3; (**c–f**) 2/2/4; (**g**) 2/2/5; (**h**) 2/3/1.

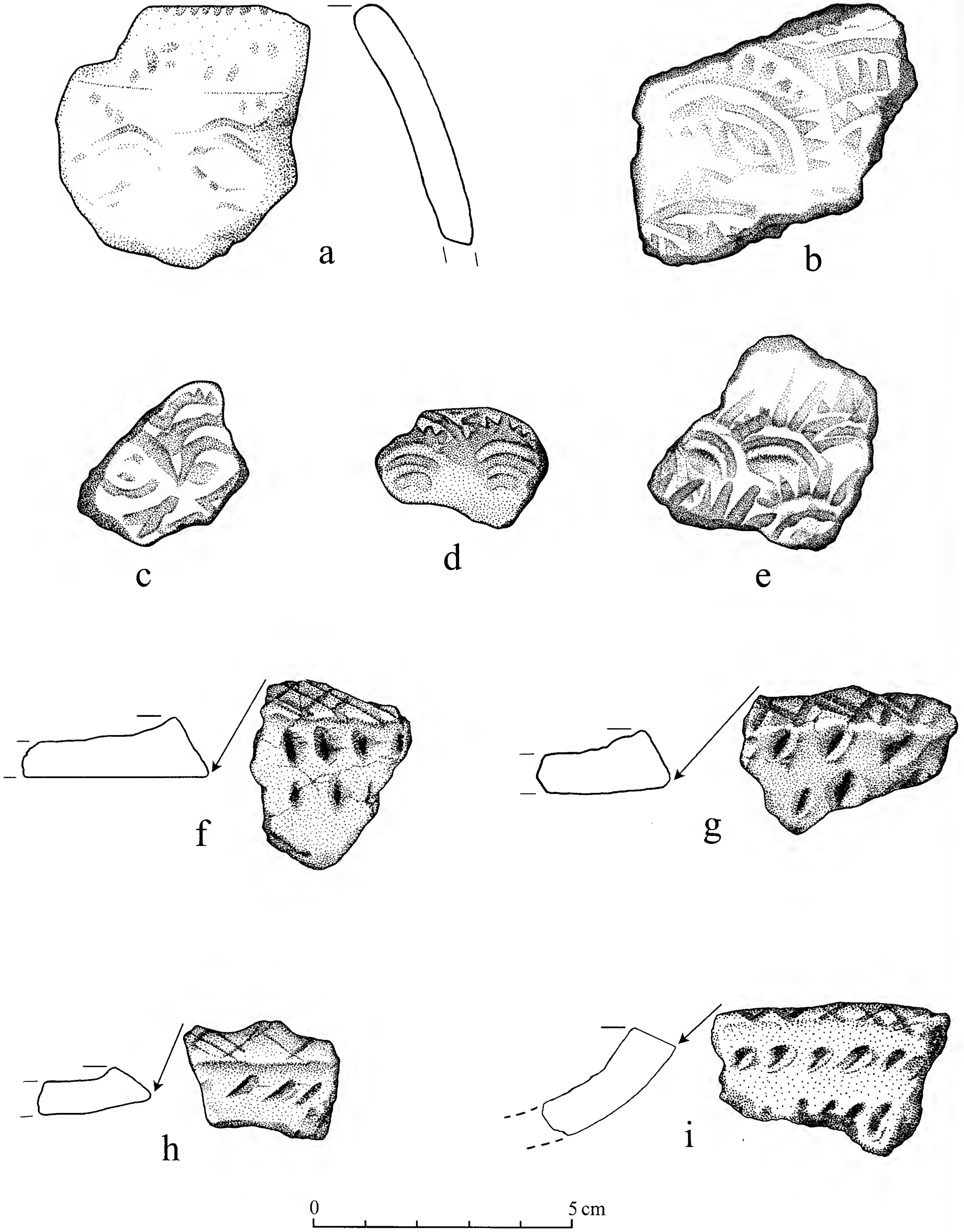

FIG. 7.6. Sumalo Ware decorated sherds from NGRP 46: (**a–d**) 1/B/2/2; (**e**) 3/3/3; (**f**, **g**) 2/2/1; (**h**) 2/2/2; (**i**) 2/2/4.

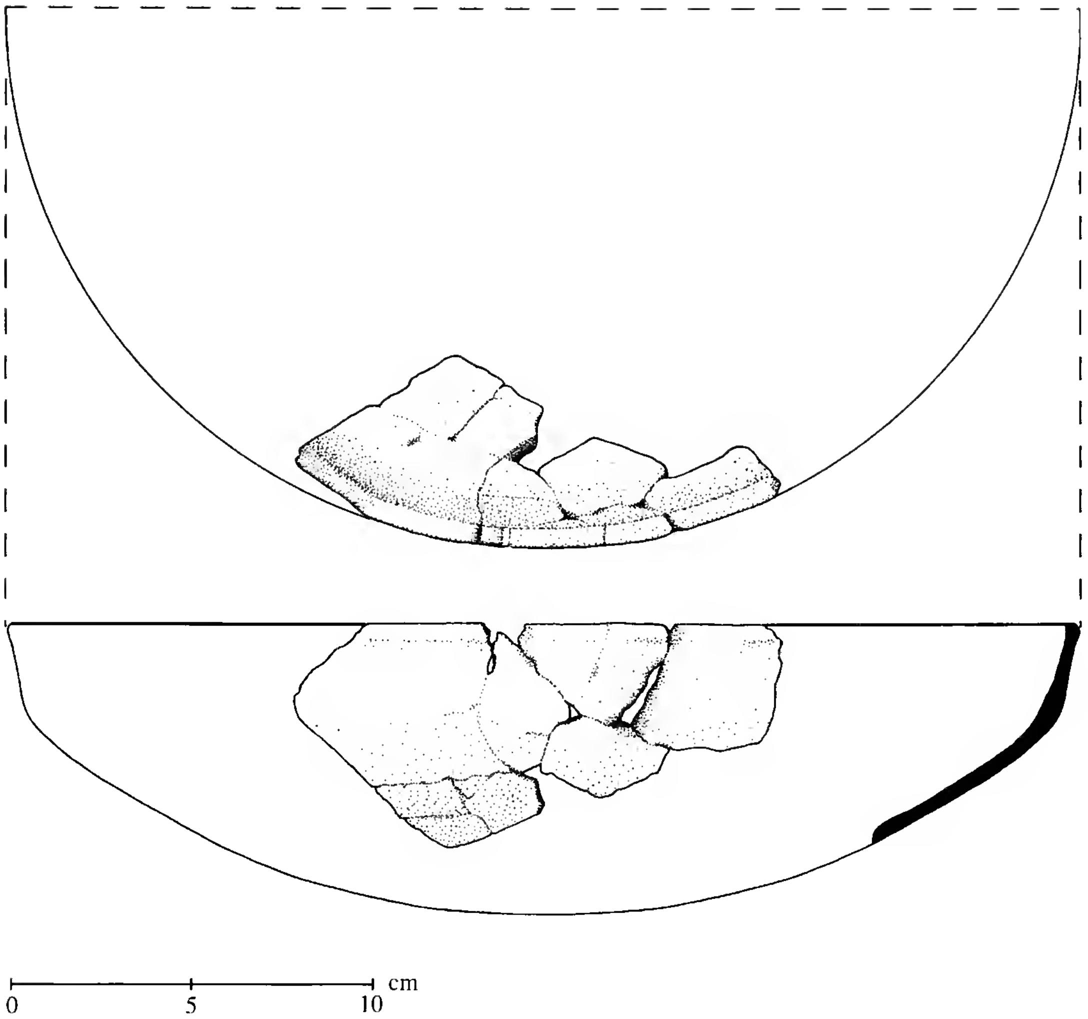

FIG. 7.7. Sumalo Ware shallow basin or platter from NGRP 23, 2A/C1/C3.

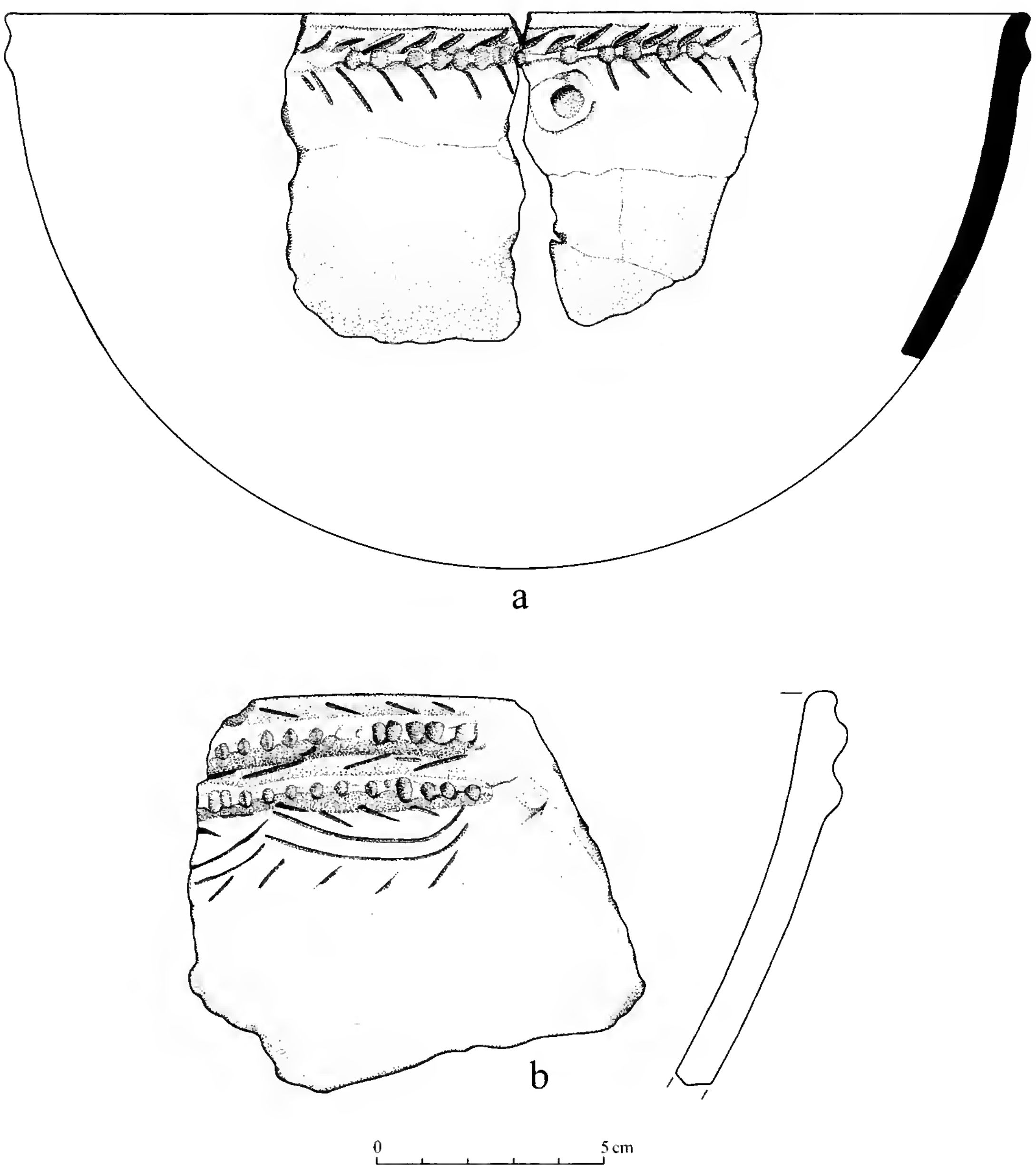

FIG. 7.8. Aiser Ware bowls from NGRP 46: (**a**) 3/3/1; (**b**) 1/C/2/1.

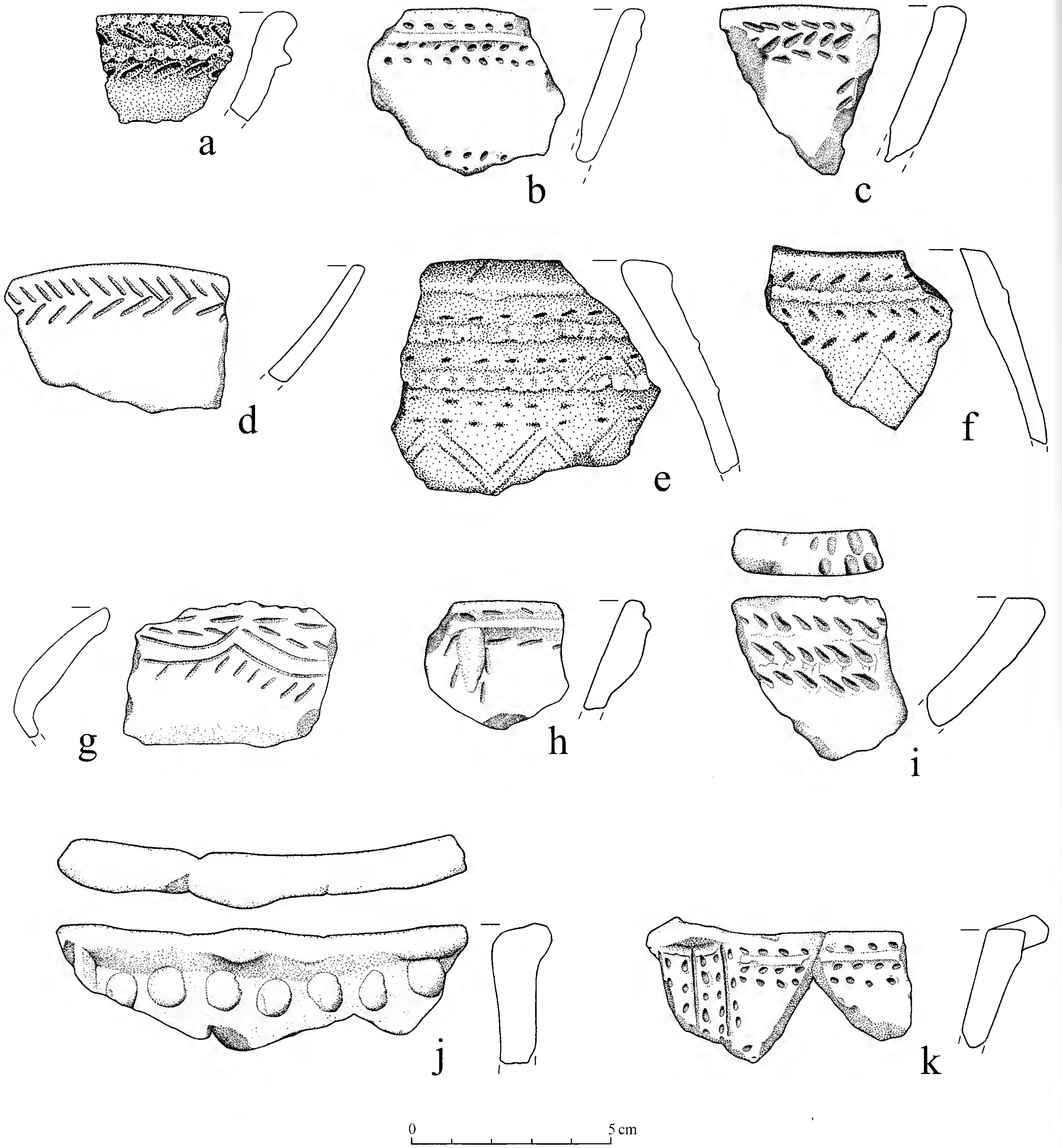

Fig. 7.9. Aiser Ware decorated sherds: (**a**) Tumleo, Nyapin; (**b**) 3/2/2; (**c**) 3/3/1; (**d**) 3/2/4 (**b–d** from NGRP 46); (**e**, **f**) Wom/Aiser; (**g**) 1/B/2/1; (**h**) 1/A/2/2; (**i**) 3/2/3; (**j**) 1/B/2/1; (**k**) 3/2/2 (**g–k** from NGRP 46).

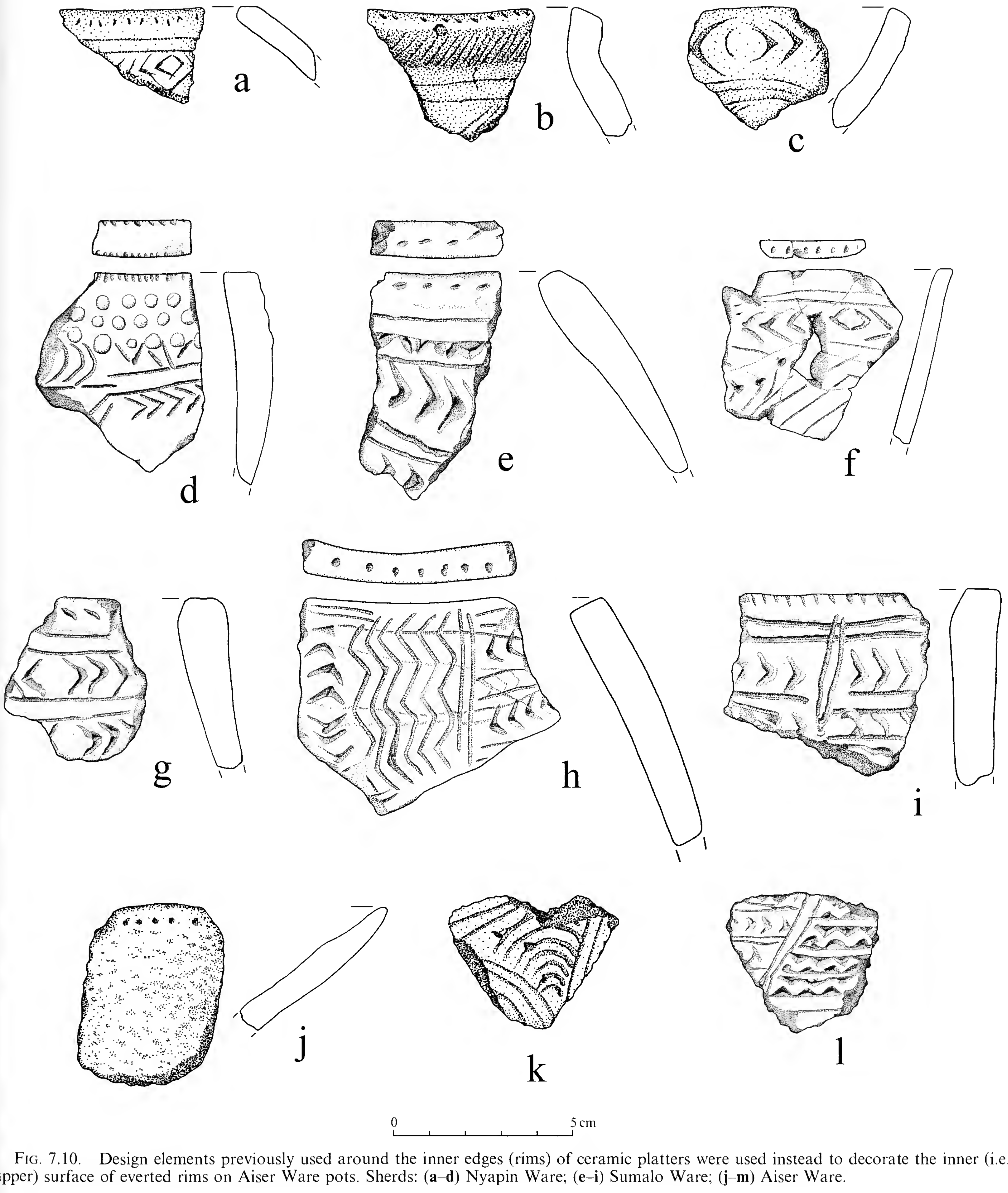

FIG. 7.10. Design elements previously used around the inner edges (rims) of ceramic platters were used instead to decorate the inner (i.e., upper) surface of everted rims on Aiser Ware pots. Sherds: **(a–d)** Nyapin Ware; **(e–i)** Sumalo Ware; **(j–m)** Aiser Ware.

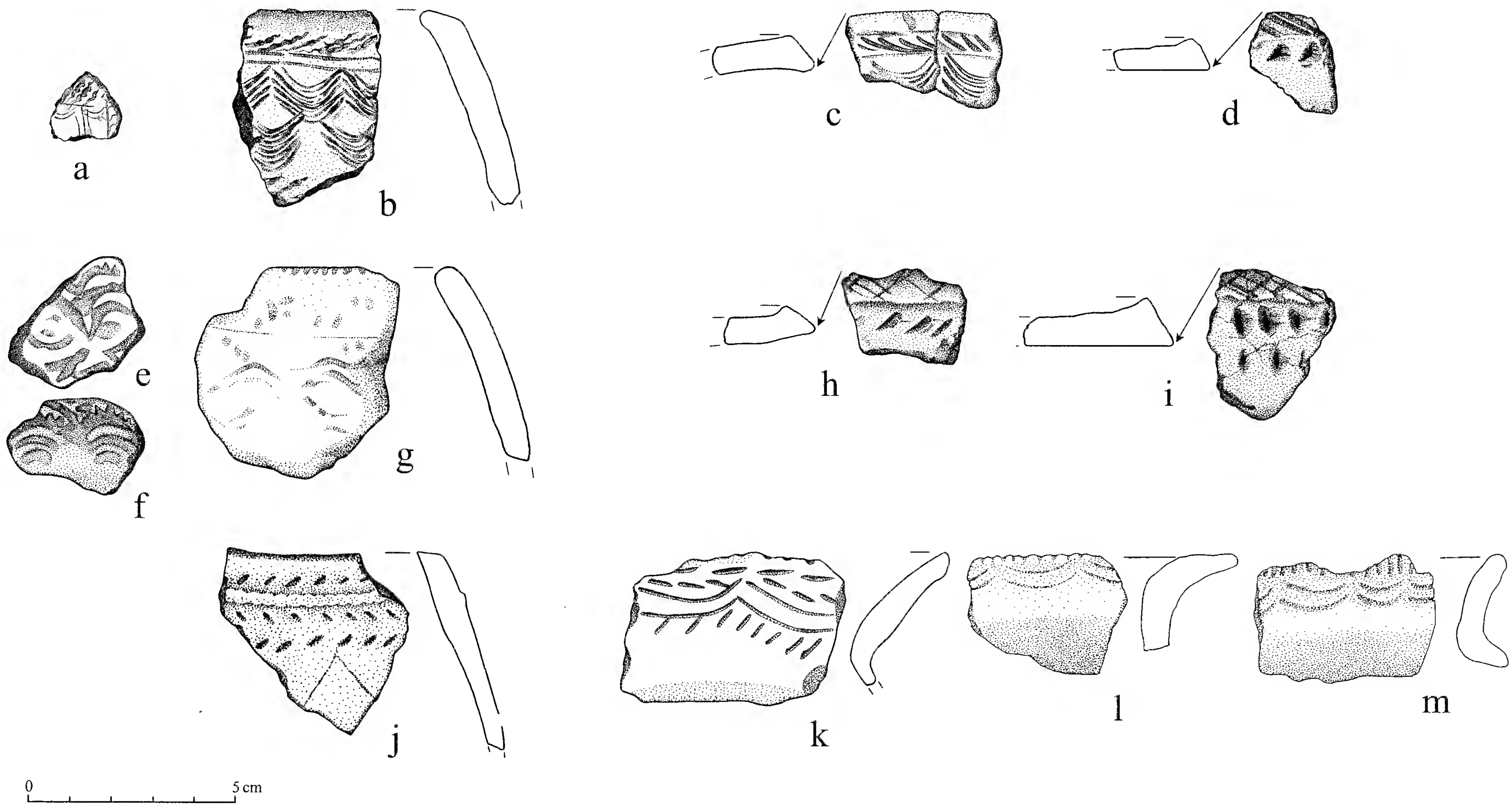

FIG. 7.11. Wain Ware decorated sherds: (**a**) Tumleo, Wain; (**b**, **c**) Tumleo, Nyapin; (**d**) 1/A/1/2; (**e**) 1/A–C/surface; (**f**) 1/B/1/2; (**g**) 1/A/2/1; (**h**) 1/A–C/surface; (**i**) 1/B/1/2 (**d–i** from NGRP 46); (**j**) Tumleo, Wain; (**k**) Tumleo, Nyapin; (**l**) 1/A–C/surface (from NGRP 46).

Table 7.4. Distribution of design characteristics across the four pottery wares (NGRP 46, test pits 1–3; sherds in test pit 1, squares A–C, surface have not been included; see Table 7.3).

	WAIN		AISER		SUMALO		NYAPIN		
	No.	%	No.	%	No.	%	No.	%	Totals (no.)
B-11	1	0.03	8	0.28	6	0.21	14	0.48	29
B-12	2	0.07	7	0.25	10	0.36	9	0.32	28
B-13	6	0.08	54	0.76	5	0.07	6	0.08	71
B-14	0	0.00	8	0.47	7	0.41	2	0.12	17
D-21	9	0.03	150	0.56	77	0.29	32	0.12	268
D-22	0	0.00	2	0.05	2	0.05	36	0.90	40
D-23	0	0.00	4	0.33	0	0.00	8	0.67	12
D-31	32	0.33	64	0.66	1	0.01	0	0.00	97
D-32	19	0.45	20	0.48	2	0.05	1	0.02	42
D-33	5	1.00	0	0.00	0	0.00	0	0.00	5
D-34	52	0.70	19	0.26	0	0.00	3	0.04	74
D-41	17	0.08	189	0.89	6	0.03	1	0.00	213
D-42	8	0.06	126	0.93	1	0.01	0	0.00	135
D-43	26	0.67	12	0.31	1	0.03	0	0.00	39
D-51	14	0.15	77	0.82	3	0.03	0	0.00	94
D-52	19	0.08	208	0.86	11	0.05	3	0.01	241
D-53	7	0.09	66	0.85	2	0.03	3	0.04	78
L-11	2	0.02	77	0.87	7	0.08	3	0.03	89
L-21	55	0.68	20	0.25	3	0.04	3	0.04	81
L-31	8	0.47	7	0.41	1	0.06	1	0.06	17
L-41	1	0.03	15	0.43	5	0.14	14	0.40	35
L-51	1	0.06	16	0.94	0	0.00	0	0.00	17
T-11	20	0.21	69	0.73	5	0.05	0	0.00	94
T-21	9	0.32	16	0.57	3	0.11	0	0.00	28
T-22	12	0.60	8	0.40	0	0.00	0	0.00	20
T-23	7	0.64	4	0.36	0	0.00	0	0.00	11
T-31	1	0.03	31	0.97	0	0.00	0	0.00	32
T-41	0	0.00	40	1.00	0	0.00	0	0.00	40
T-61	4	0.07	56	0.92	1	0.02	0	0.00	61
T-62	24	0.92	2	0.08	0	0.00	0	0.00	26
T-71	9	0.06	153	0.94	1	0.01	0	0.00	163
T-81	7	0.78	1	0.11	1	0.11	0	0.00	9
T-82	11	0.73	4	0.27	0	0.00	0	0.00	15
M-11	1	0.03	30	0.97	0	0.00	0	0.00	31
M-12	0	0.00	6	1.00	0	0.00	0	0.00	6
M-13	0	0.00	4	1.00	0	0.00	0	0.00	4
M-14	0	0.00	3	1.00	0	0.00	0	0.00	3
M-20	0	0.00	0	0.00	0	0.00	1	1.00	1
M-21	0	0.00	2	0.20	0	0.00	8	0.80	10
M-22	1	0.06	13	0.72	2	0.11	2	0.11	18
M-23	0	0.00	4	0.29	4	0.29	6	0.43	14
M-24	0	0.00	15	1.00	0	0.00	0	0.00	15
M-25	5	0.07	69	0.93	0	0.00	0	0.00	74
M-26	2	0.05	36	0.95	0	0.00	0	0.00	38
M-31	6	0.75	2	0.25	0	0.00	0	0.00	8
M-32	1	0.33	2	0.67	0	0.00	0	0.00	3
Totals	**404**	**0.17**	**1,719**	**0.70**	**167**	**0.07**	**156**	**0.06**	**2,446**

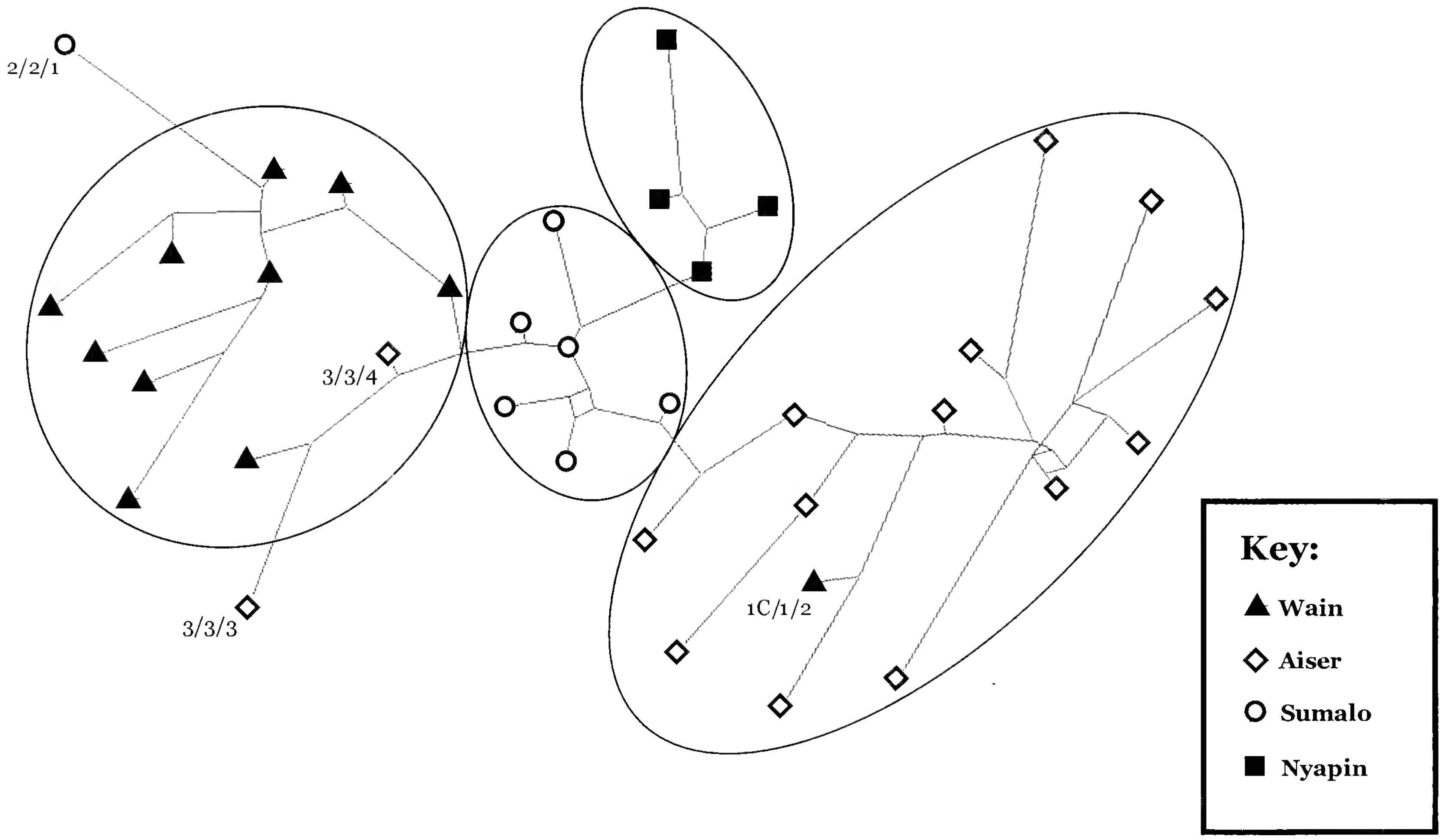

FIG. 7.12. Unrooted phylogenetic tree of the excavation units in test pits 1–3 at NGRP 46 on Tumleo Island constructed using Network 4.5.0.2 and the median-joining algorithm of Bandelt et al. (1999). The ellipses around the nodes are not confidence limits, but mark only the complementary distributions of the four wares.

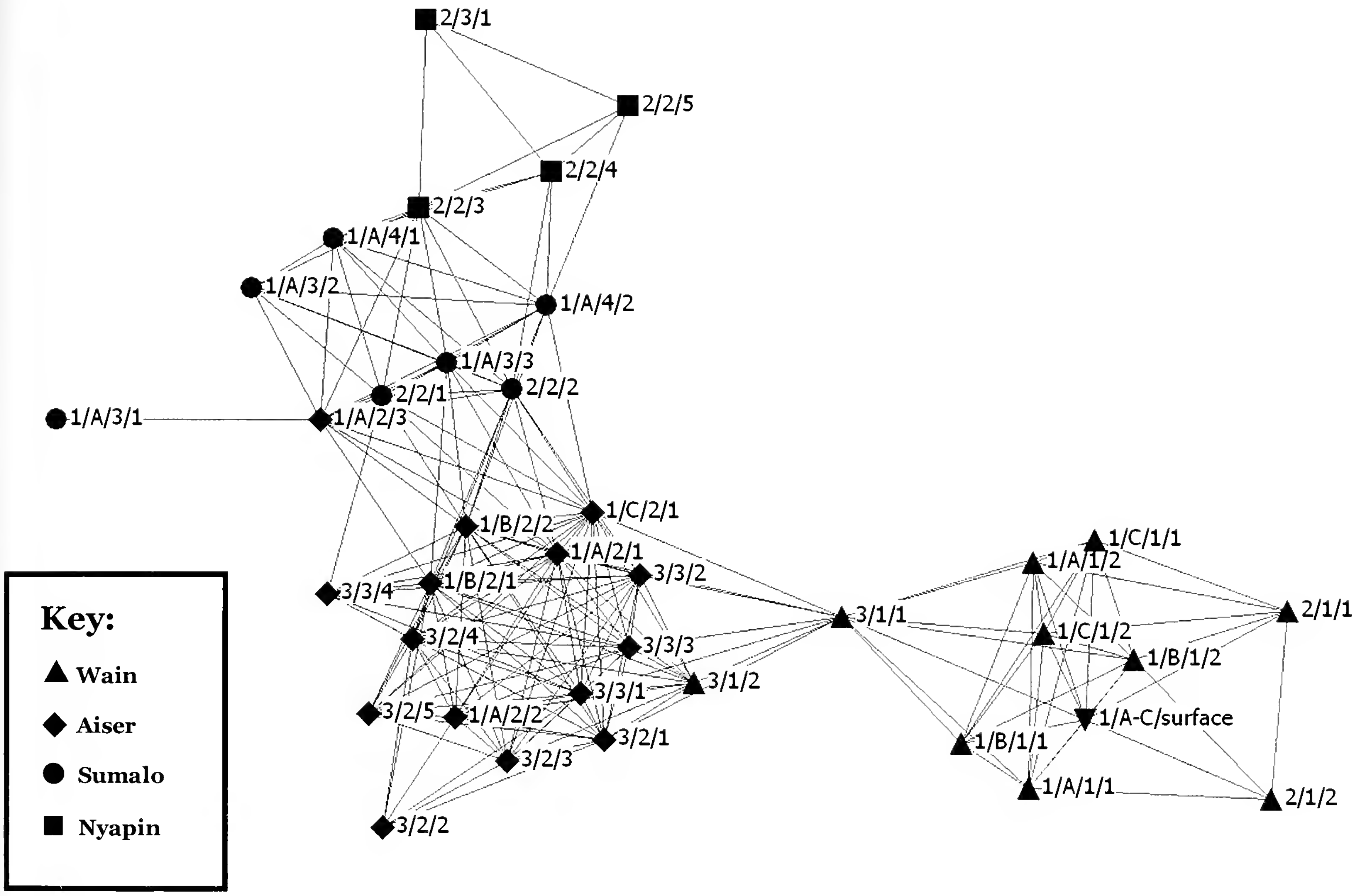

FIG. 7.13. Spring-embedding network array of the excavation units (nodes) at NGRP 46 using Pearson's correlation values derived from the trait frequencies in Table 7.3 when the edge (i.e., linkage) weighting is set at a value of ≥0.417, the threshold at which all nodes are connected to at least one other node.

TABLE 7.5. Weighted synopsis of the distribution of design characteristics across the four pottery wares (see Table 7.4).

	B-11	B-12	B-13	B-14	D-21	D-22	D-23	D-31	D-32	D-33	D-34	D-41	D-42	D-43	D-51	D-52	D-53	L-11	L-21	L-31	L-41	L-51
WAIN								*	**	*	***			**					***	*		
AISER	*	*	***	*	***			***	**		*	***	***	*	***	***	***	***	*	*	**	**
SUMALO	*	**		*	*																	
NYAPIN	**	*				**	*														**	

	T-11	T-21	T-22	T-23	T-31	T-41	T-61	T-62	T-71	T-81	T-82	M-11	M-12	M-13	M-14	M-20	M-21	M-22	M-23	M-24	M-25	M-26	M-31	M-32
WAIN	*	*	**	*				**		*	**												*	
AISER	***	**	*		**	**	***		***			**	*					**		**	***	**		
SUMALO																								
NYAPIN																	*		*					

* Represents ≥20% and 5 specimens or more.

** Represents ≥35% and 10 specimens or more.

*** Represents ≥50% and 50 specimens or more.

TABLE 7.6. Pearson's correlation values among the four proposed prehistoric wares.

Ware	Wain	Aiser	Sumalo	Nyapin
Wain	1.00	0.18	0.02	−0.13
Aiser	0.18	1.00	0.42	0.07
Sumalo	0.02	0.42	1.00	0.62
Nyapin	−0.13	0.07	0.62	1.00

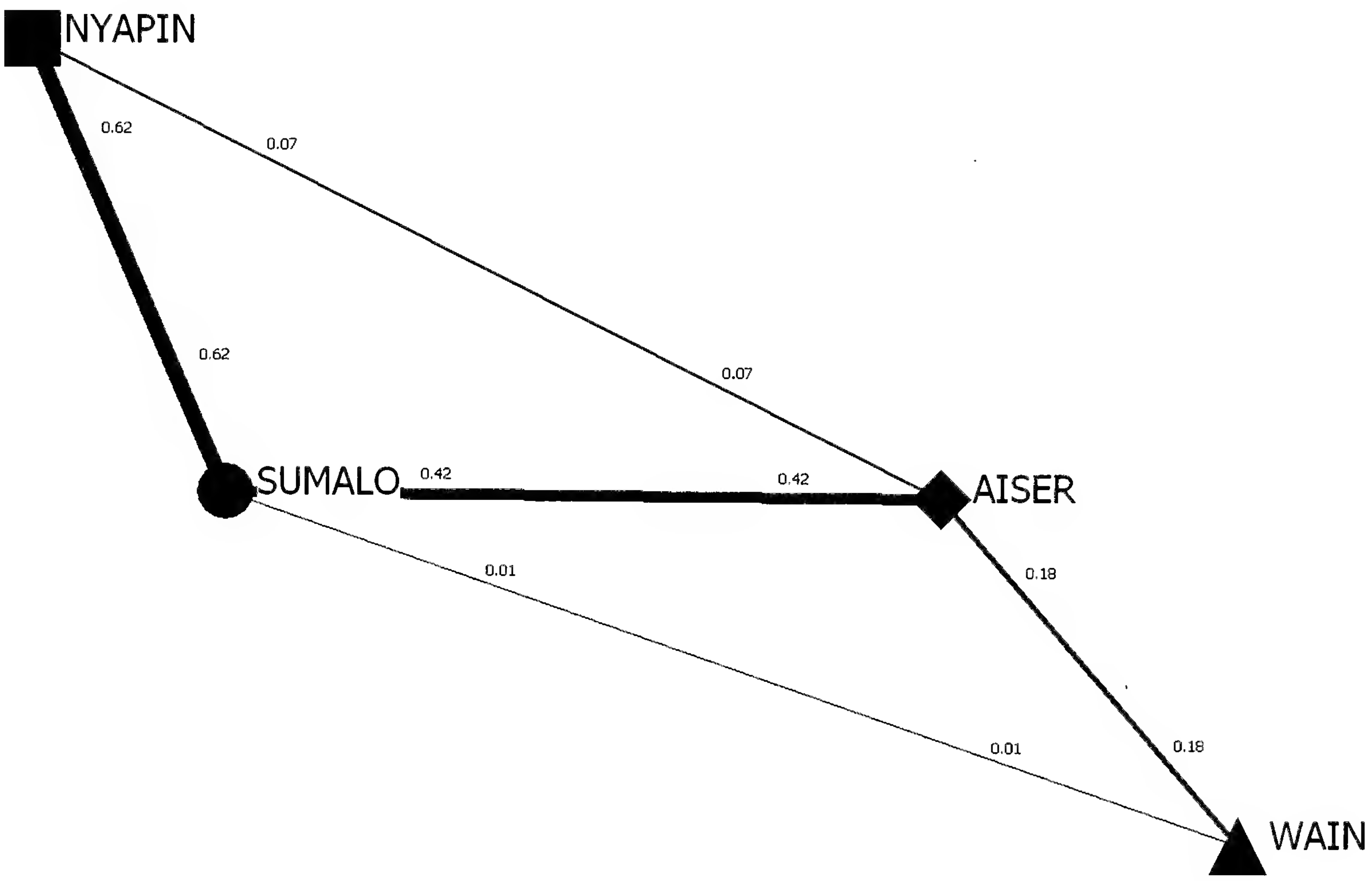

FIG. 7.14. Network mapping of the Pearson's correlation values among the four proposed wares.

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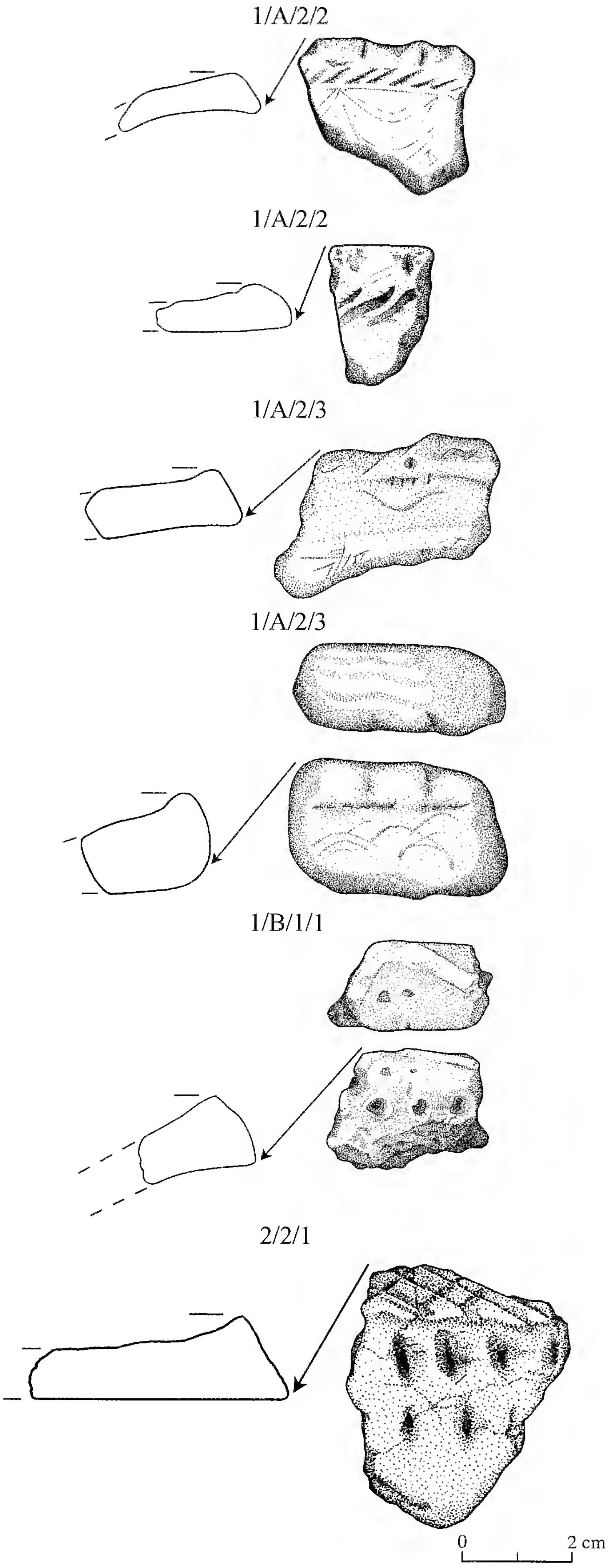
B-11

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	4	406	1
	1/A/2/3	2	171	1
Sumalo	1/A/3/1	1	18	6
	1/A/3/2	1	51	2
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	1	32	3
	1/B/1/2		68	
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2	1	272	<1
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1		285	
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1	2	180	1
	2/2/2	2	59	3
Nyapin	2/2/3	1	119	1
	2/2/4	7	126	6
	2/2/5	1	34	3
	2/3/1	5	77	7
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4	2	90	2
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	

platter sherds



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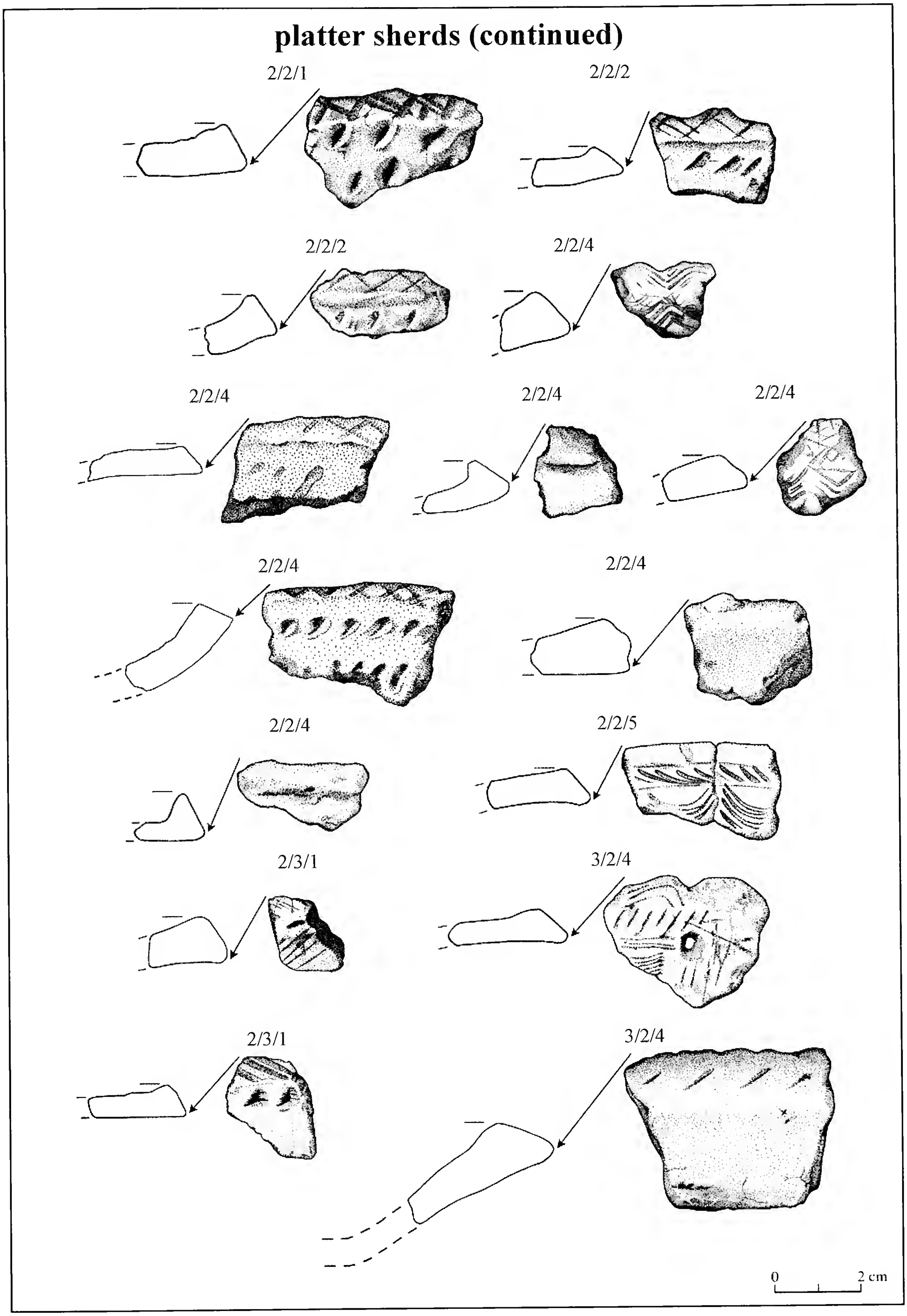


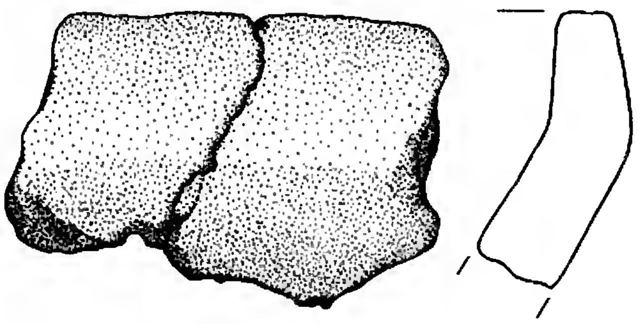
Appendix 7.1: *Continued.*

B-12

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	1	406	<1
	1/A/2/3	3	171	2
Sumalo	1/A/3/1	2	18	11
	1/A/3/2	2	51	4
	1/A/3/3	2	98	2
	1/A/4/1	1	55	2
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2	1	68	2
Aiser	1/B/2/1	1	300	<1
Aiser/Sumalo	1/B/2/2	1	272	<1
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1		285	
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1	2	180	3
	2/2/2	1	59	2
Nyapin	2/2/3	2	119	2
	2/2/4	6	126	5
	2/2/5	1	34	3
	2/3/1		77	
Wain	3/1/1	1	29	4
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2	1	51	2
	3/3/3		34	
	3/3/4		11	

carination

1/A/3/1



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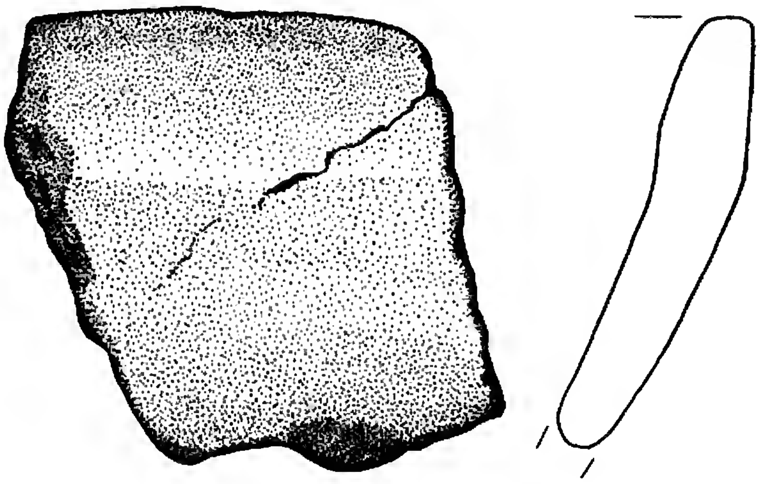

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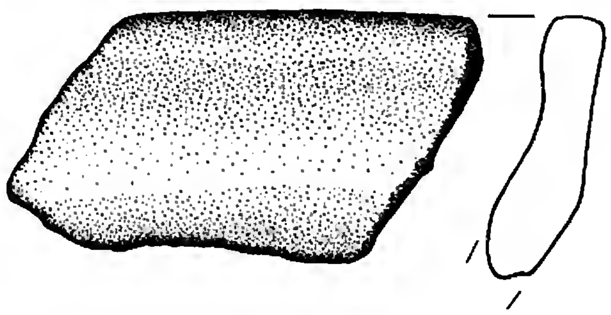

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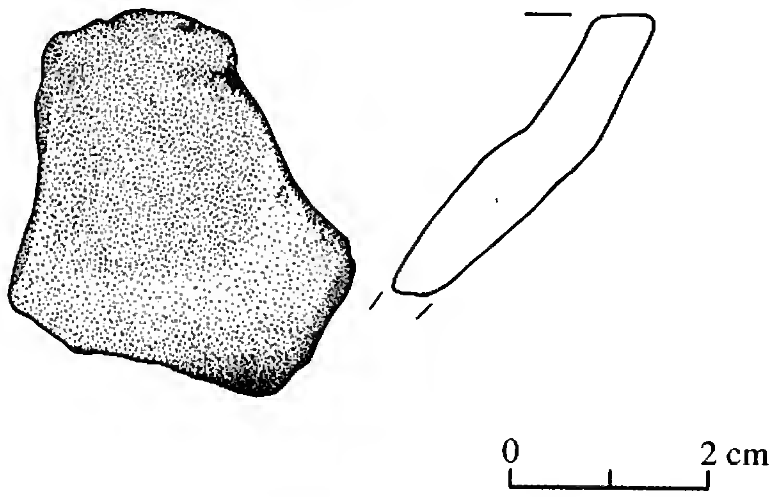

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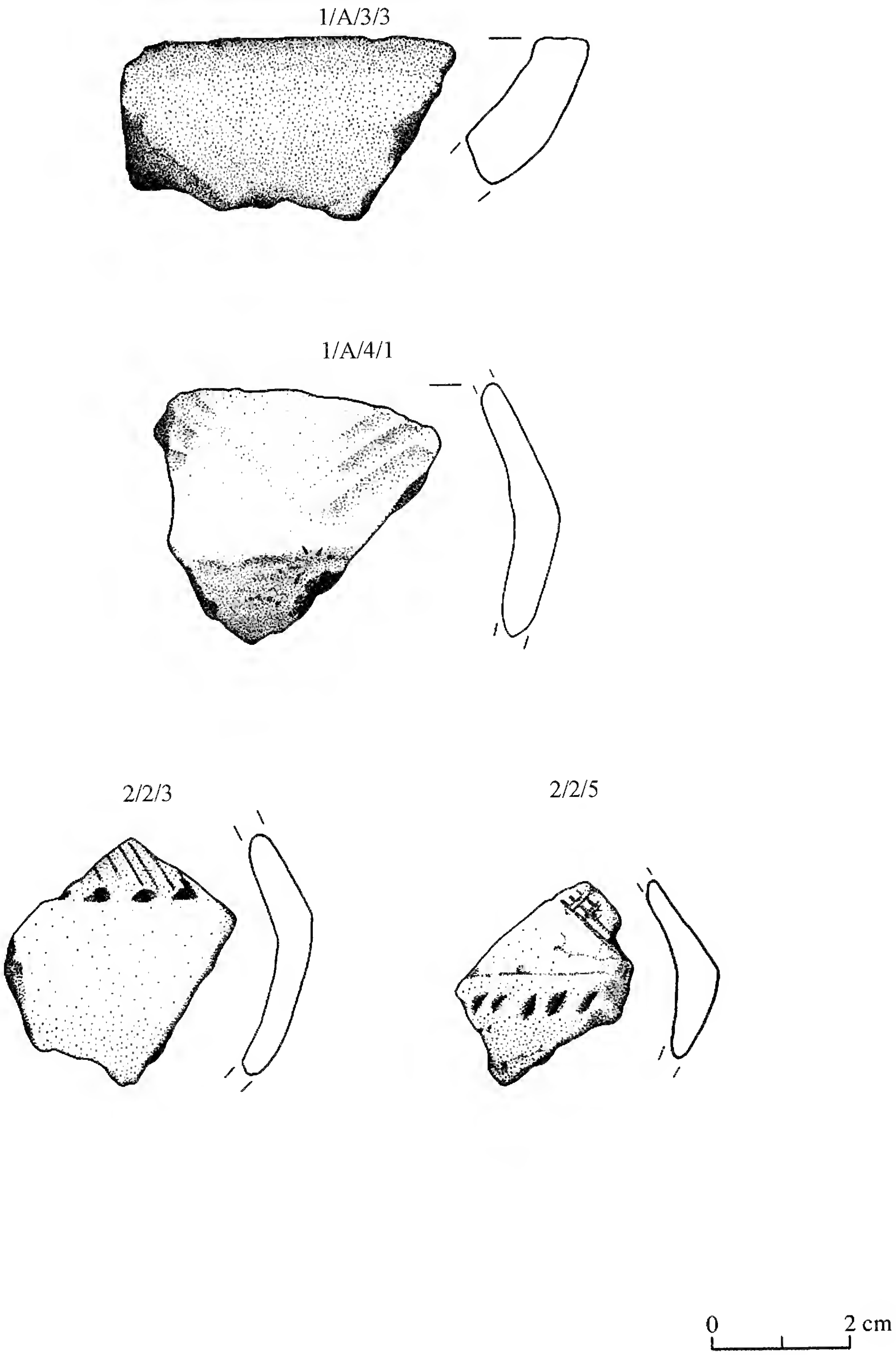


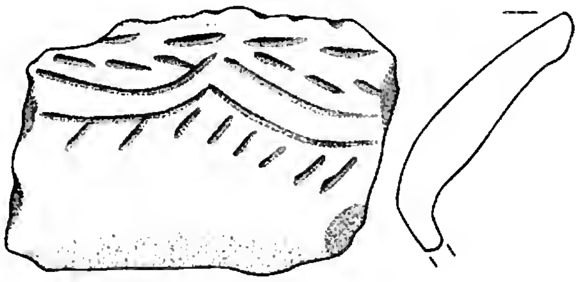
Appendix 7.1: ***Continued.***

B-13

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2	4	60	7
Aiser	1/A/2/1	1	122	1
	1/A/2/2	24	406	6
	1/A/2/3	6	171	4
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1	2	55	4
	1/A/4/2		57	
Wain	1/B/1/1	1	32	3
	1/B/1/2		68	
Aiser	1/B/2/1	7	300	2
Aiser/Sumalo	1/B/2/2	4	272	1
Wain	1/C/1/1		32	
	1/C/1/2	1	62	2
Aiser	1/C/2/1	5	285	2
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1	3	180	2
	2/2/2	?	59	?
Nyapin	2/2/3	1	119	1
	2/2/4	3	126	2
	2/2/5	1	34	3
	2/3/1	1	77	1
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2	2	20	10
	3/2/3	1	72	1
	3/2/4	1	90	1
	3/2/5	1	27	4
	3/3/1		36	
	3/3/2	2	51	4
	3/3/3		34	
	3/3/4		11	

everted rim

1/B/2/1



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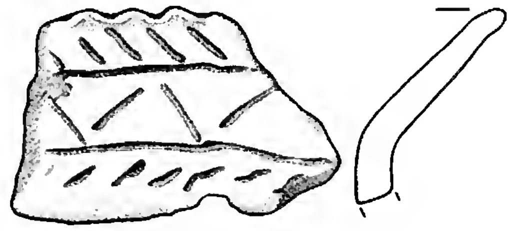
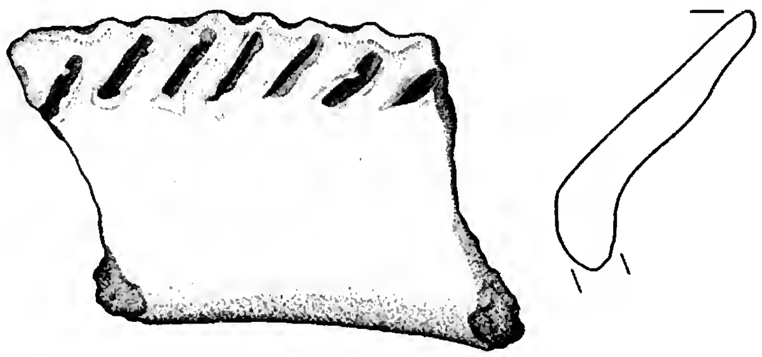
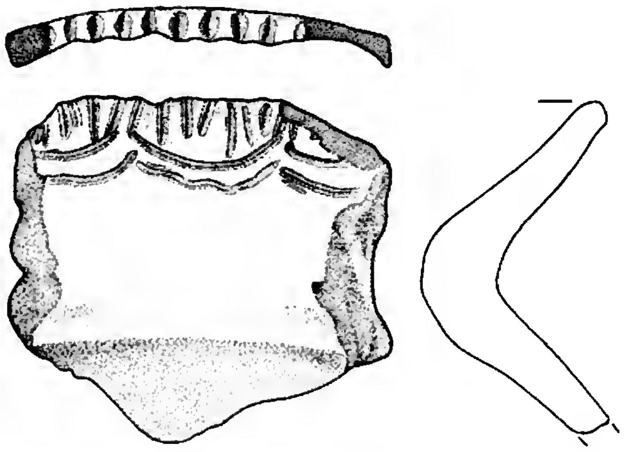


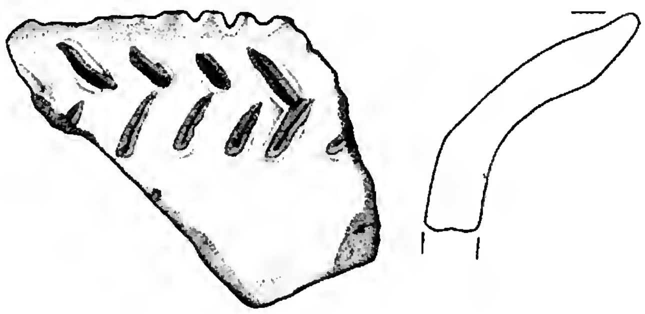
1/C/1/2



3/2/2



3/3/2



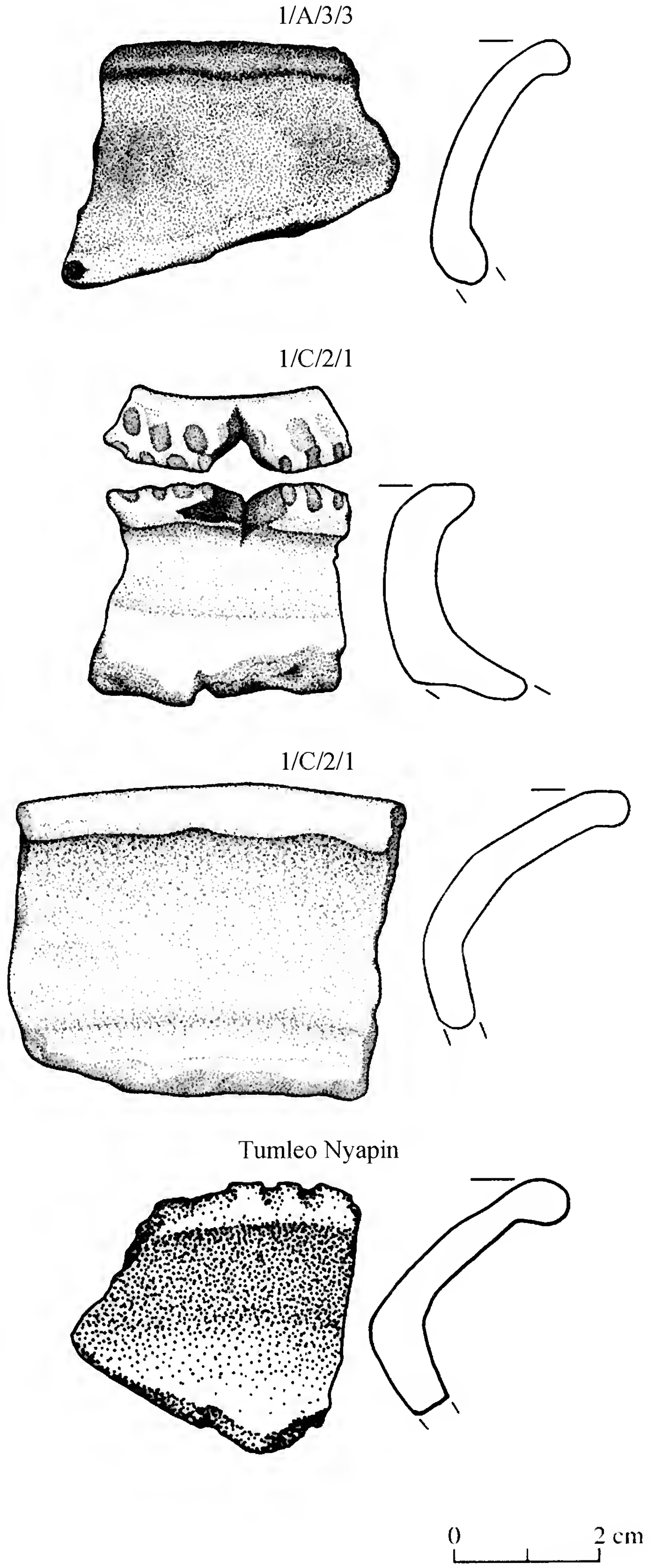
0 2 cm

Appendix 7.1: *Continued.*

B-14

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1	1	122	1
	1/A/2/2	4	406	1
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3	1	98	1
	1/A/4/1	3	55	6
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2		68	
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2		272	
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1	2	285	1
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1	3	180	2
	2/2/2		59	
Nyapin	2/2/3	1	119	1
	2/2/4		126	
	2/2/5		34	
	2/3/1	1	77	1
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2	1	20	5
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	

rolled everted rim



Appendix 7.1: *Continued.*

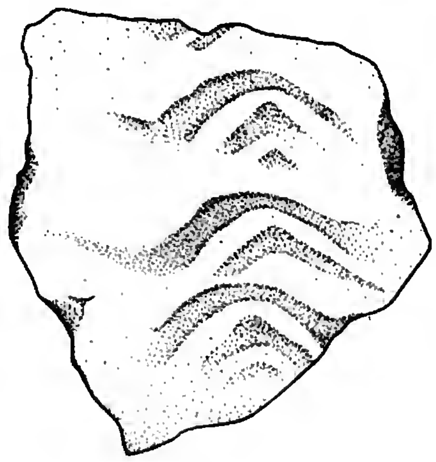
D-21 — broad-toothed scoring

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1	1	19	5
	1/A/1/2		60	
Aiser	1/A/2/1	9	122	7
	1/A/2/2	21	406	5
	1/A/2/3	13	171	8
Sumalo	1/A/3/1	1	18	6
	1/A/3/2	9	51	18
	1/A/3/3	14	98	14
	1/A/4/1	10	55	19
	1/A/4/2	5	57	9
Wain	1/B/1/1	1	32	3
	1/B/1/2	3	68	4
Aiser	1/B/2/1	30	300	10
Aiser/Sumalo	1/B/2/2	24	272	9
Wain	1/C/1/1		32	
	1/C/1/2	3	62	5
Aiser	1/C/2/1	35	285	12
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1	33	180	18
	2/2/2	5	59	9
Nyapin	2/2/3	21	119	18
	2/2/4	8	126	6
	2/2/5	2	34	34
	2/3/1	1	77	1
Wain	3/1/1		29	
	3/1/2	1	16	8
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3	1	72	1
	3/2/4	6	90	7
	3/2/5	3	27	11
	3/3/1	1	36	3
	3/3/2	5	51	10
	3/3/3	1	34	3
	3/3/4	1	11	9

1/A/2/2

1/A/4/1

1/B/2/1

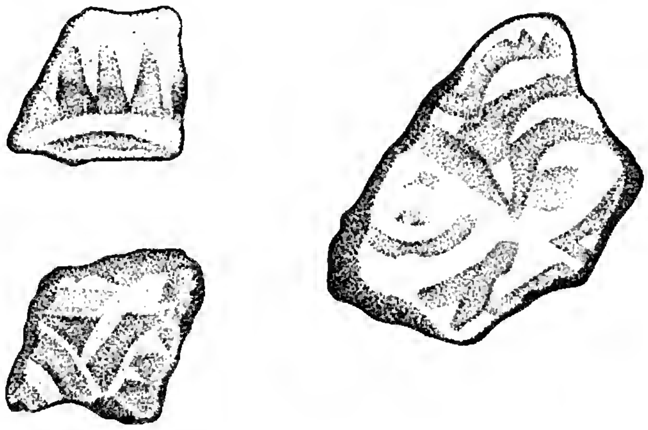


0 2 cm

Appendix 7.1: *Continued.*

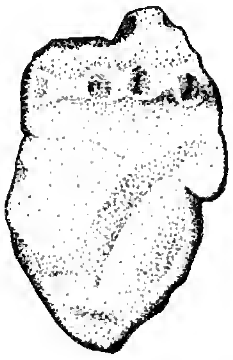
broad-toothed scoring (continued)

1/B/2/2



1/C/2/1

2/2/1



3/3/3

0 2 cm

Appendix 7.1: *Continued.*

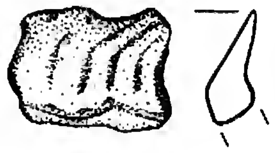
D-22

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	1	406	<1
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1	1	55	2
	1/A/4/2	1	57	2
Wain	1/B/1/1		32	
	1/B/1/2		68	
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2		272	
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1		285	
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3	11	119	9
	2/2/4	14	126	11
	2/2/5	4	34	12
	2/3/1	7	77	9
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4	1	90	1
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	

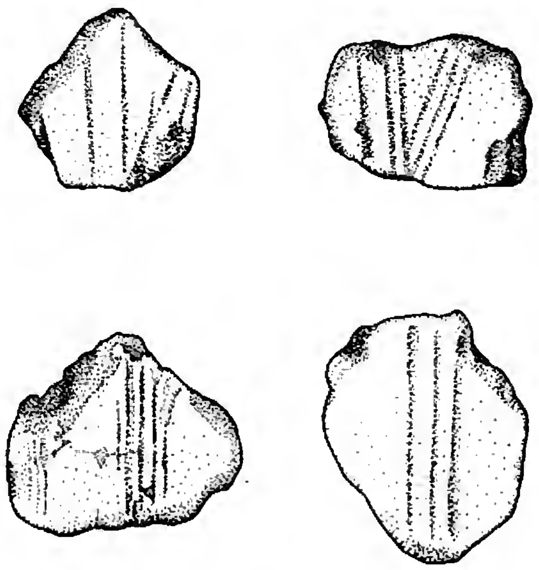
fine-line scoring

2/2/4

2/2/4



2/2/4



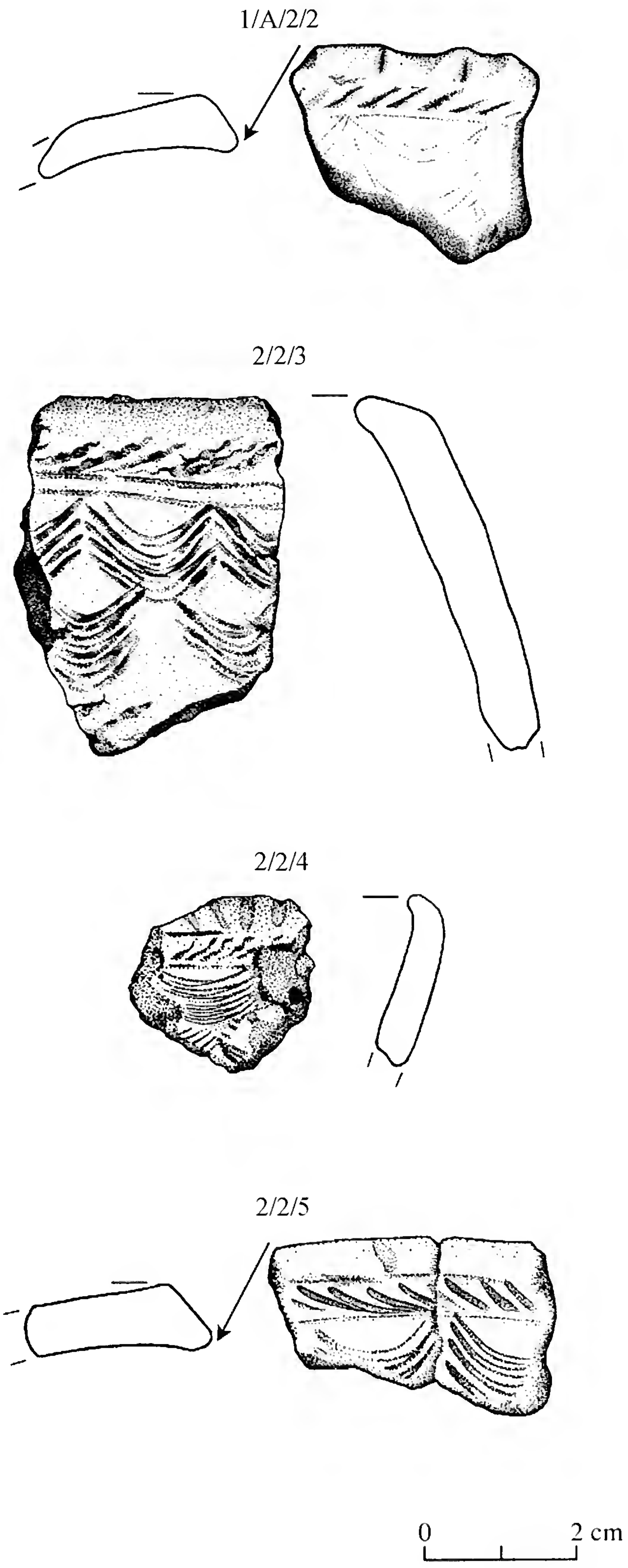
0 2 cm

Appendix 7.1: *Continued.*

D-23

fine-line wavy scoring

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	1	406	<1
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2		68	
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2		272	
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1	1	285	<1
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3	3	119	3
	2/2/4	1	126	1
	2/2/5	1	34	3
	2/3/1	3	77	4
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4	1	90	1
	3/2/5		27	
	3/3/1		36	
	3/3/2	1	51	2
	3/3/3		34	
	3/3/4		11	

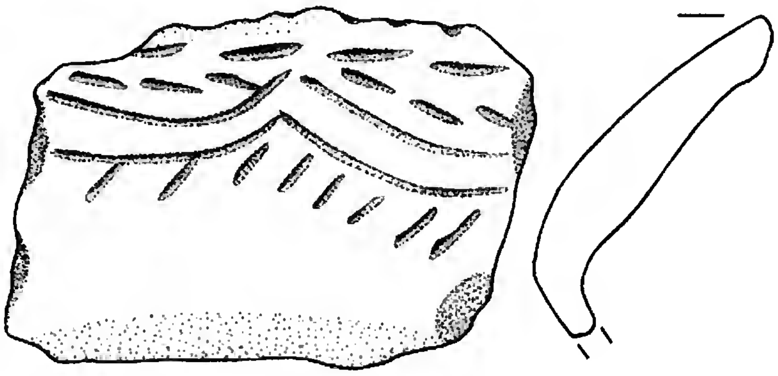


Appendix 7.1: *Continued.*

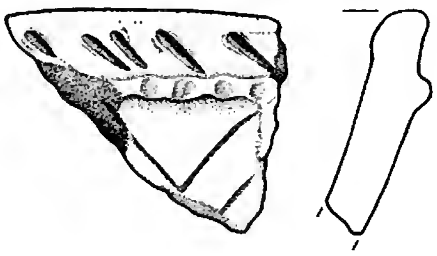
	D-31			
	NGRP-46	***no.***	***total***	***%***
surface	1/A-C/surface	1	53	2
Wain	1/A/1/1	1	19	5
	1/A/1/2	8	60	13
Aiser	1/A/2/1	4	122	3
	1/A/2/2	13	406	3
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	4	32	13
	1/B/1/2	5	68	7
Aiser	1/B/2/1	14	300	5
Aiser/Sumalo	1/B/2/2	5	272	2
Wain	1/C/1/1	3	32	9
	1/C/1/2	8	62	13
Aiser	1/C/2/1	11	285	4
Wain	2/1/1	1	10	10
	2/1/2	1	34	3
Sumalo	2/2/1	1	180	1
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	1	29	4
	3/1/2		16	
Aiser	3/2/1	4	23	17
	3/2/2	3	20	15
	3/2/3	1	72	1
	3/2/4	2	90	2
	3/2/5		27	
	3/3/1	5	36	14
	3/3/2	1	51	2
	3/3/3		34	
	3/3/4	1	11	10

hanging incised or appliqué lines

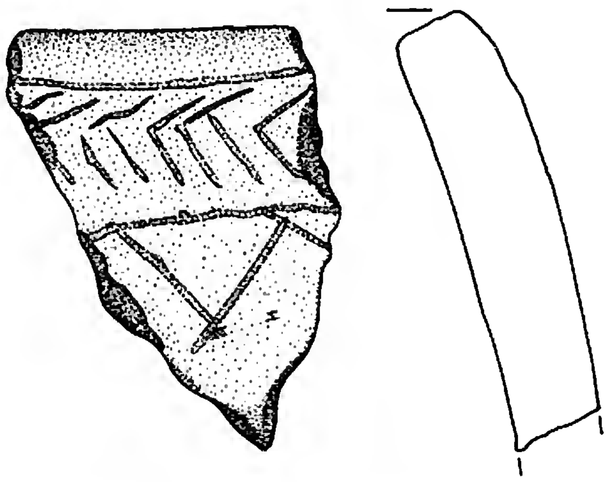
1/B/2/1



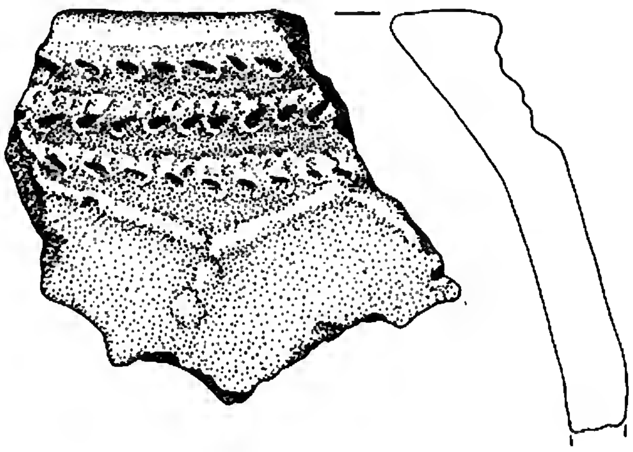
1/B/2/1



Tumleo Ainamul



Wom Aiser



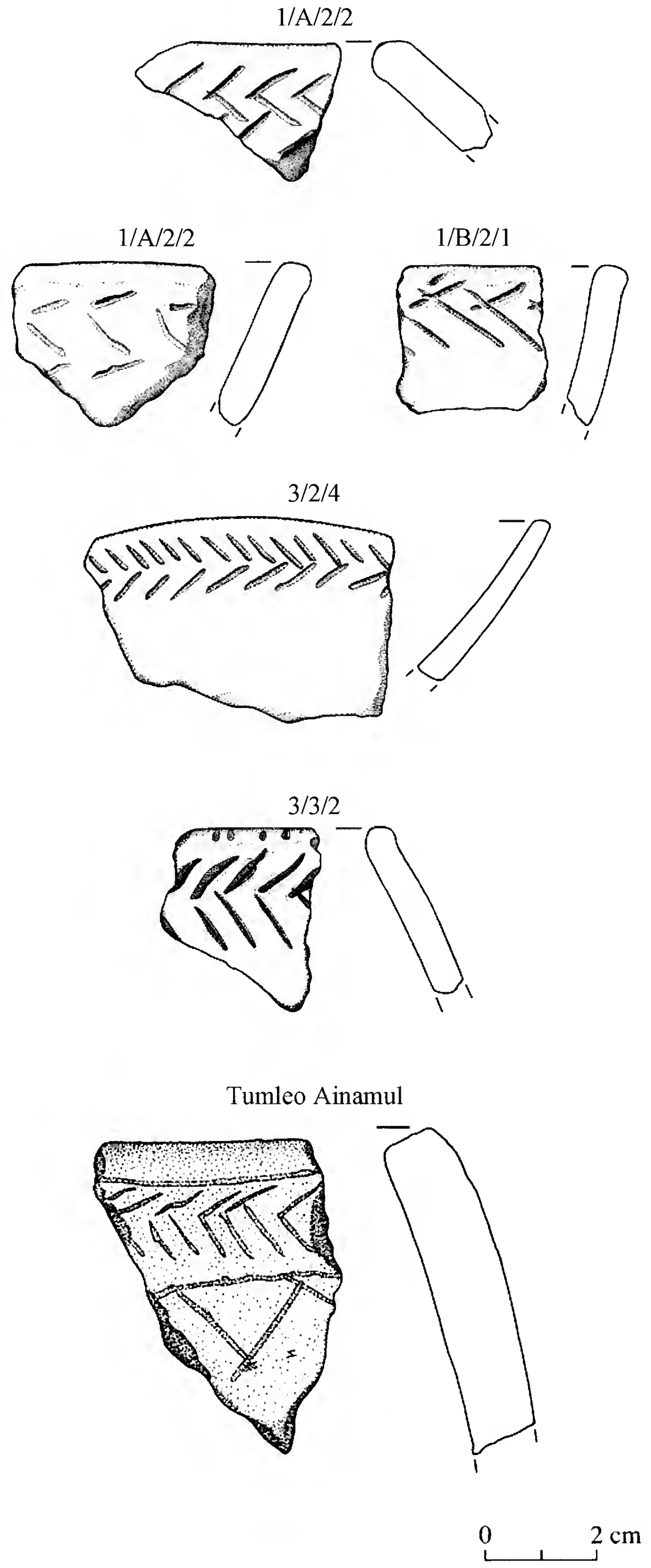
0 2 cm

Appendix 7.1: ***Continued.***

D-32

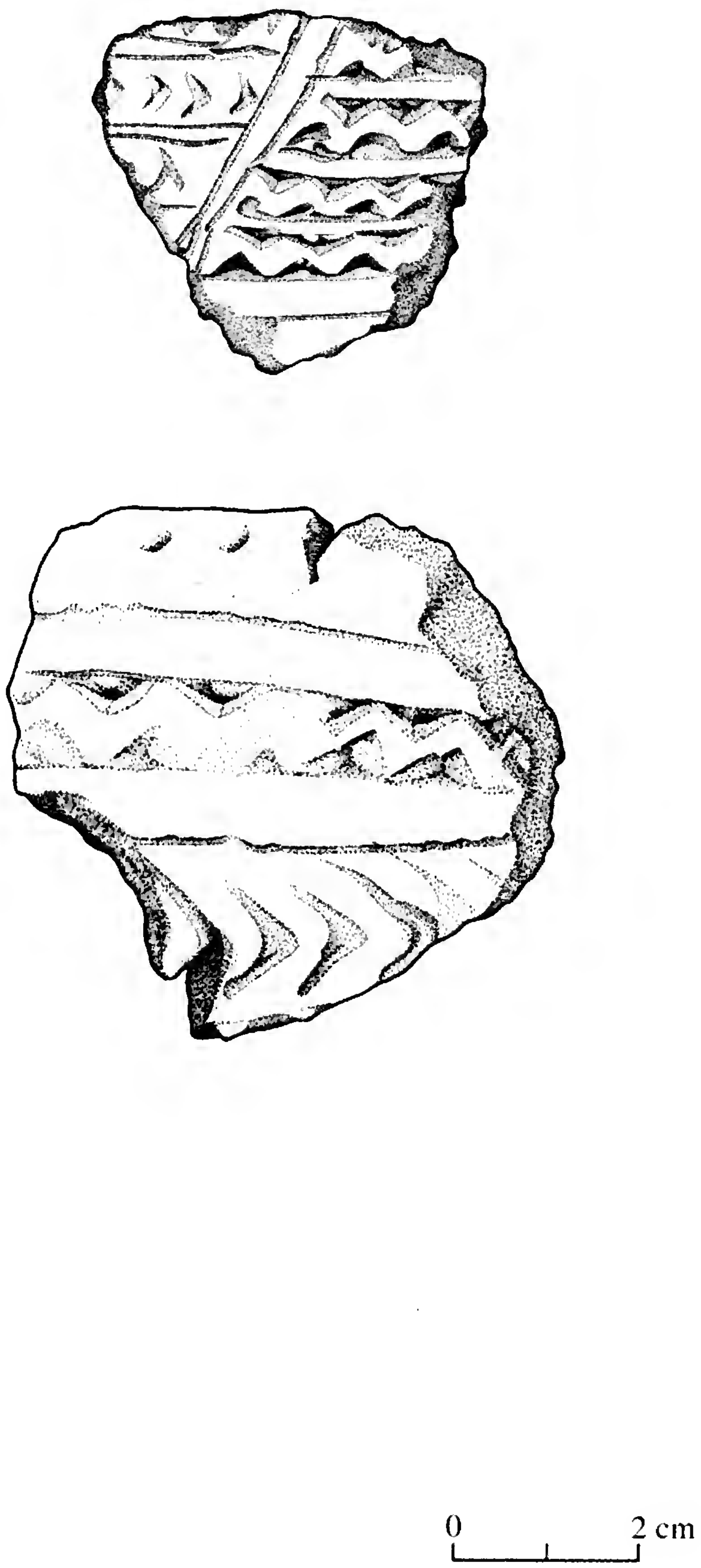
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface	1	53	2
Wain	1/A/1/1	6	19	32
	1/A/1/2	2	60	3
Aiser	1/A/2/1	3	122	3
	1/A/2/2	6	406	2
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2	4	68	6
Aiser	1/B/2/1	1	300	<1
Aiser/Sumalo	1/B/2/2	2	272	1
Wain	1/C/1/1		32	
	1/C/1/2	4	62	6
Aiser	1/C/2/1	2	285	1
Wain	2/1/1		10	
	2/1/2	1	34	3
Sumalo	2/2/1	2	180	1
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4	1	126	1
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	1	29	3
	3/1/2	1	16	6
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4	2	90	2
	3/2/5		27	
	3/3/1		36	
	3/3/2	2	51	4
	3/3/3	1	34	3
	3/3/4	1	11	10

herringbone incised



Appendix 7.1: ***Continued.***

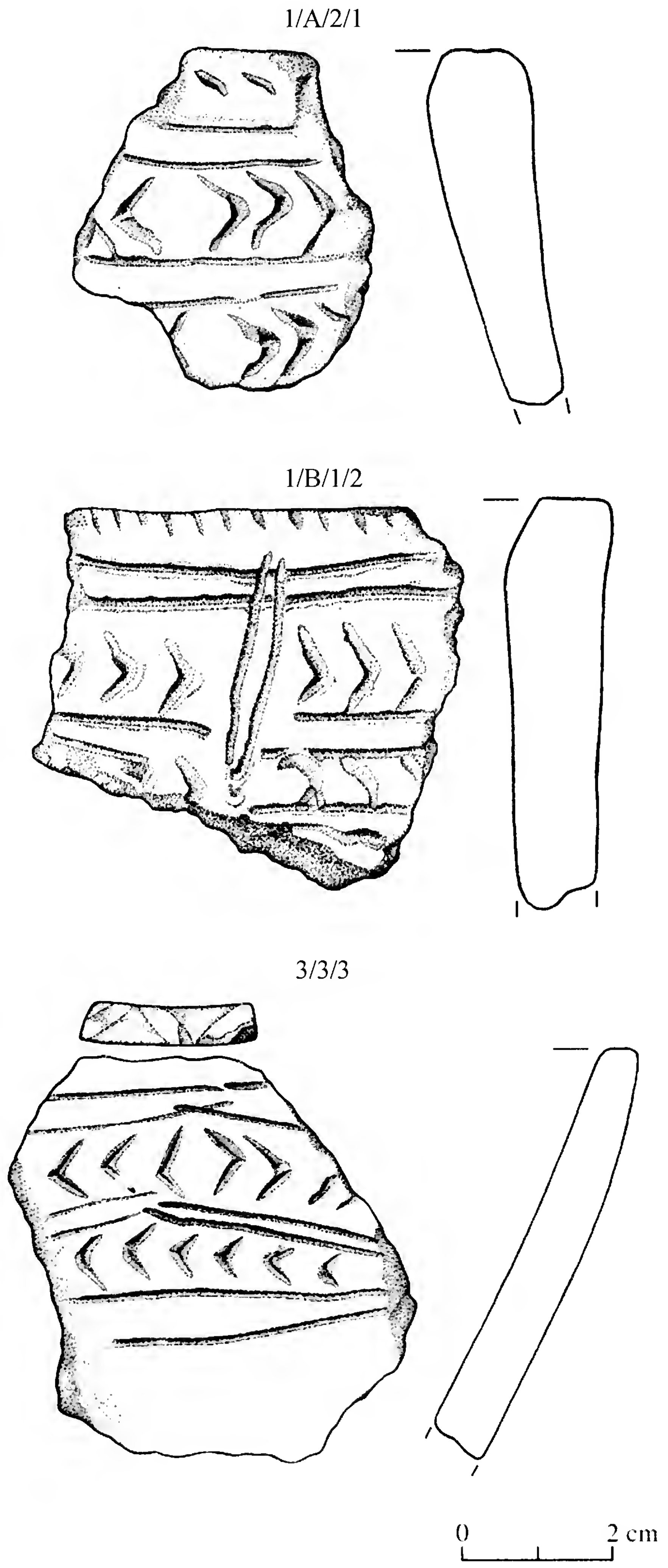
	D-33				rick-rack gouged
	NGRP-46	*no.*	*total*	*%*	
surface	1/A-C/surface	3	53	7	
Wain	1/A/1/1		19		
	1/A/1/2	3	60	5	
Aiser	1/A/2/1		122		
	1/A/2/2		406		
	1/A/2/3		171		1/A-C/Surface
Sumalo	1/A/3/1		18		
	1/A/3/2		51		
	1/A/3/3		98		
	1/A/4/1		55		
	1/A/4/2		57		
Wain	1/B/1/1	1	32	3	
	1/B/1/2		68		
Aiser	1/B/2/1		300		
Aiser/Sumalo	1/B/2/2		272		
Wain	1/C/1/1		32		
	1/C/1/2		62		
Aiser	1/C/2/1		285		
Wain	2/1/1		10		
	2/1/2		34		
Sumalo	2/2/1		180		
	2/2/2		59		
Nyapin	2/2/3		119		
	2/2/4		126		
	2/2/5		34		
	2/3/1		77		
Wain	3/1/1	1	29	3	
	3/1/2		16		
Aiser	3/2/1		23		
	3/2/2		20		
	3/2/3		72		
	3/2/4		90		
	3/2/5		27		
	3/3/1		36		
	3/3/2		51		
	3/3/3		34		
	3/3/4		11		



Appendix 7.1: ***Continued.***

	D-34			
	NGRP-46	***no.***	***total***	***%***
surface	1/A-C/surface	9	53	16
Wain	1/A/1/1	4	19	21
	1/A/1/2	12	60	20
Aiser	1/A/2/1	5	122	4
	1/A/2/2	9	406	2
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	3	32	9
	1/B/1/2	19	68	28
Aiser	1/B/2/1	1	300	<1
Aiser/Sumalo	1/B/2/2		272	
Wain	1/C/1/1	3	32	9
	1/C/1/2	5	62	8
Aiser	1/C/2/1		285	
Wain	2/1/1	1	10	10
	2/1/2	2	34	6
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3	2	119	2
	2/2/4		126	
	2/2/5	1	34	3
	2/3/1		77	
Wain	3/1/1	3	29	10
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4	1	90	1
	3/2/5	2	27	7
	3/3/1		36	
	3/3/2		51	
	3/3/3	1	34	3
	3/3/4		11	

incised zoning



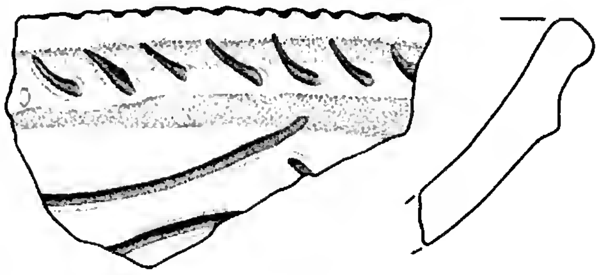
Appendix 7.1: ***Continued.***

D-41

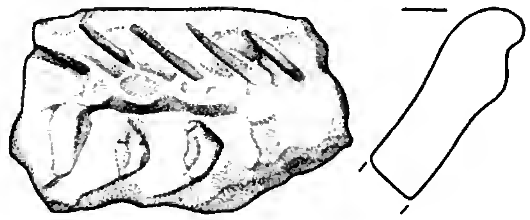
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface	3	53	6
Wain	1/A/1/1	1	19	5
	1/A/1/2	1	60	2
Aiser	1/A/2/1	10	122	9
	1/A/2/2	36	406	9
	1/A/2/3	4	171	2
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3	1	98	1
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	2	32	6
	1/B/1/2	3	68	4
Aiser	1/B/2/1	31	300	10
Aiser/Sumalo	1/B/2/2	27	272	10
Wain	1/C/1/1		32	
	1/C/1/2	1	62	2
Aiser	1/C/2/1	34	285	12
Wain	2/1/1		10	
	2/1/2	5	34	15
Sumalo	2/2/1	3	180	2
	2/2/2	2	59	3
Nyapin	2/2/3		119	
	2/2/4	1	126	1
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	2	29	7
	3/1/2	2	16	13
Aiser	3/2/1	4	23	17
	3/2/2	1	20	1
	3/2/3	9	72	13
	3/2/4	8	90	9
	3/2/5	5	27	19
	3/3/1	6	36	17
	3/3/2	8	51	16
	3/3/3	5	34	15
	3/3/4	1	11	9

rows of diagonal punctations

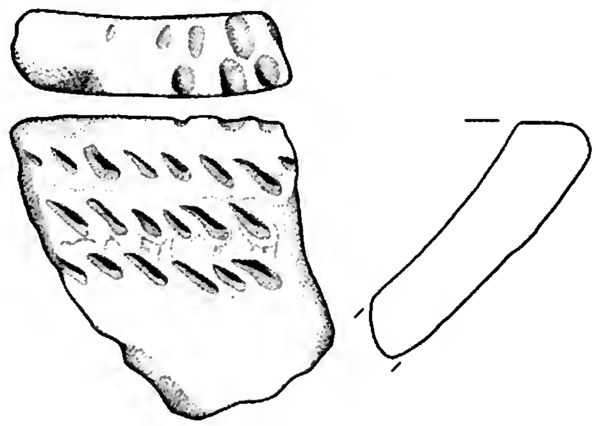
1/C/2/1



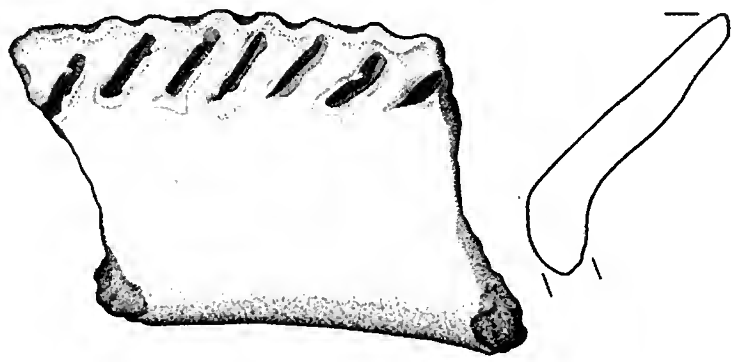
1/C/2/1



3/2/3



3/3/2



0 2 cm

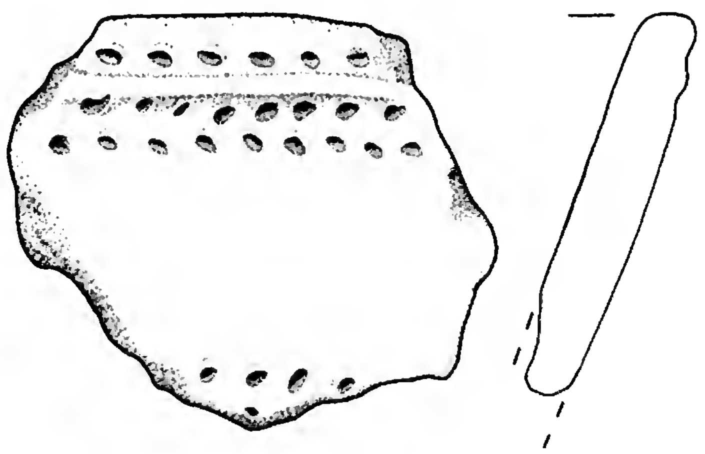
Appendix 7.1: *Continued.*

D-42

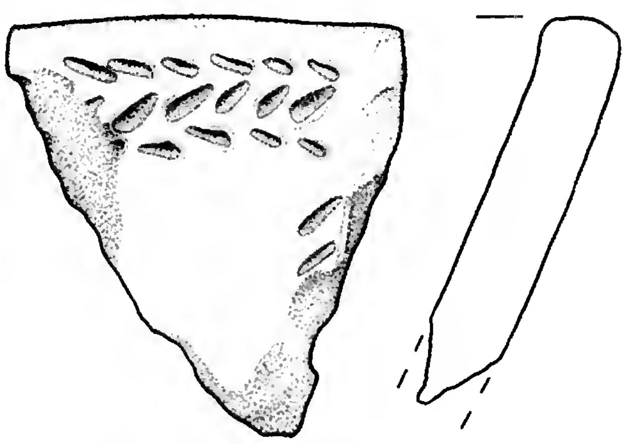
alternating rows of diagonal punctuations

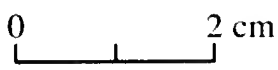
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface	1	53	2
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1	7	122	6
	1/A/2/2	29	406	7
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2	1	68	2
Aiser	1/B/2/1	42	300	14
Aiser/Sumalo	1/B/2/2	11	272	4
Wain	1/C/1/1	1	32	3
	1/C/1/2	2	62	3
Aiser	1/C/2/1	8	285	3
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2	1	59	2
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	1	29	4
	3/1/2	3	16	19
Aiser	3/2/1	2	23	9
	3/2/2	3	20	15
	3/2/3	10	72	14
	3/2/4	6	90	7
	3/2/5		27	
	3/3/1	6	36	17
	3/3/2	1	51	2
	3/3/3	1	34	3
	3/3/4		11	

3/2/2



3/3/1



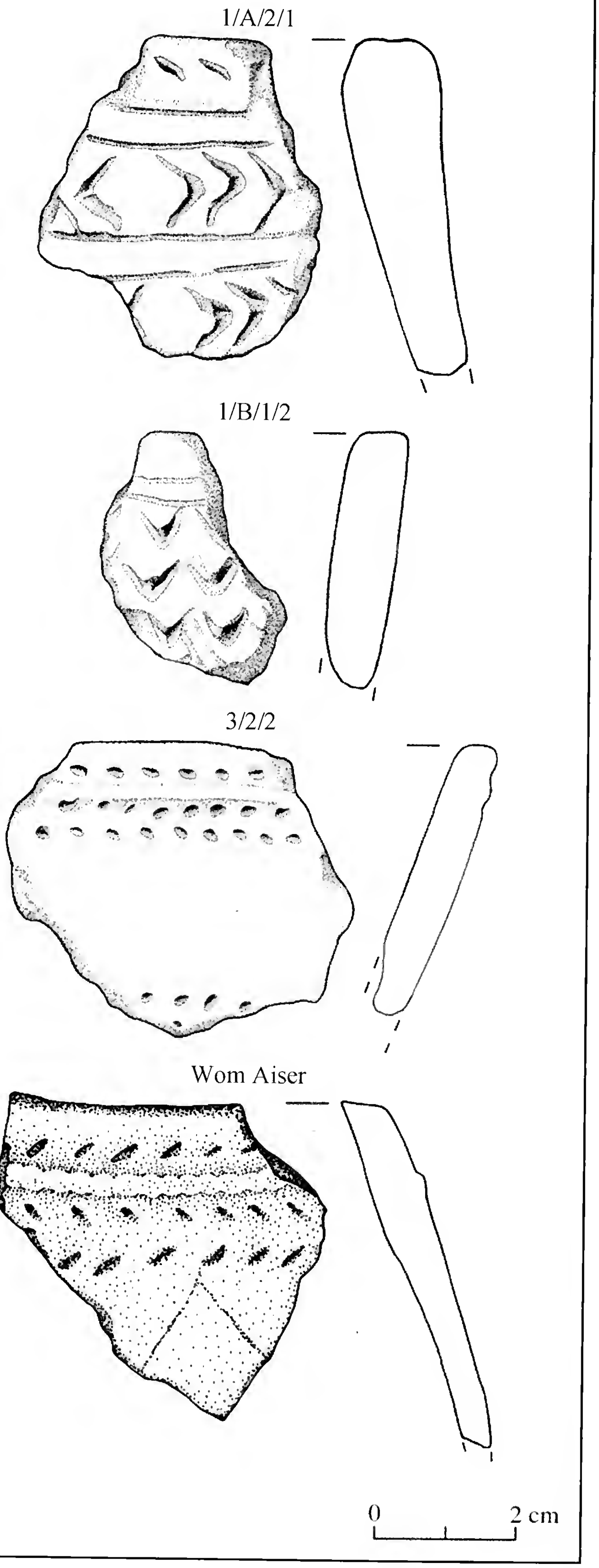


Appendix 7.1: ***Continued.***

D-43

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface	4	53	8
Wain	1/A/1/1	2	19	11
	1/A/1/2	4	60	7
Aiser	1/A/2/1	2	122	2
	1/A/2/2	1	406	<1
	1/A/2/3	2	171	1
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	2	32	6
	1/B/1/2	9	68	13
Aiser	1/B/2/1	4	300	1
Aiser/Sumalo	1/B/2/2		272	
Wain	1/C/1/1	1	32	3
	1/C/1/2	2	62	3
Aiser	1/C/2/1	2	285	<1
Wain	2/1/1	2	10	20
	2/1/2	3	34	9
Sumalo	2/2/1	1	180	1
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	1	29	3
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2	1	20	5
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	

herringbone punctate



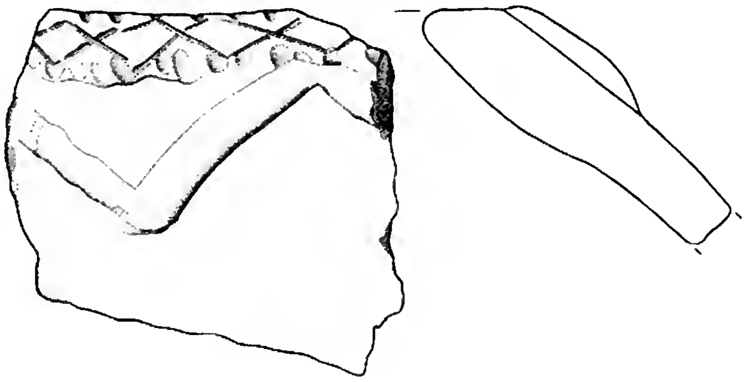
Appendix 7.1: ***Continued.***

D-51

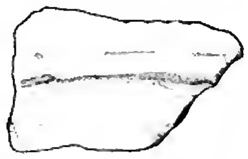
appliqué bands

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface	4	53	8
Wain	1/A/1/1	1	19	5
	1/A/1/2	3	60	5
Aiser	1/A/2/1	3	122	3
	1/A/2/2	33	406	8
	1/A/2/3	3	171	2
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3	1	98	1
	1/A/4/1	1	55	2
	1/A/4/2	1	57	2
Wain	1/B/1/1	3	32	9
	1/B/1/2	2	68	3
Aiser	1/B/2/1	14	300	7
Aiser/Sumalo	1/B/2/2	2	272	1
Wain	1/C/1/1	2	32	6
	1/C/1/2	2	62	3
Aiser	1/C/2/1	2	285	2
Wain	2/1/1		10	
	2/1/2	1	34	3
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2	3	20	15
	3/2/3	6	72	8
	3/2/4	9	90	10
	3/2/5	1	27	4
	3/3/1	1	36	3
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	

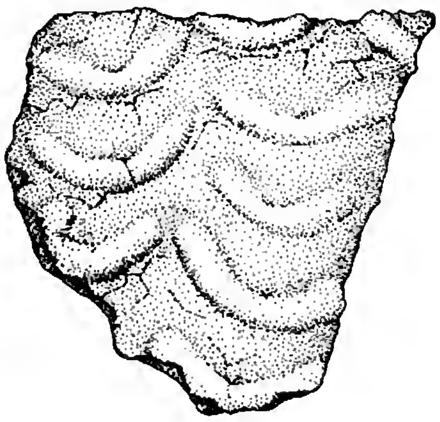
1/A-C/Surface



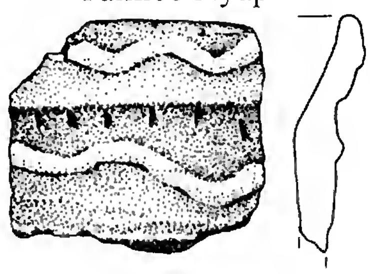
1/C/2/1



Tumleo Ainamul



Tumleo Nyapin

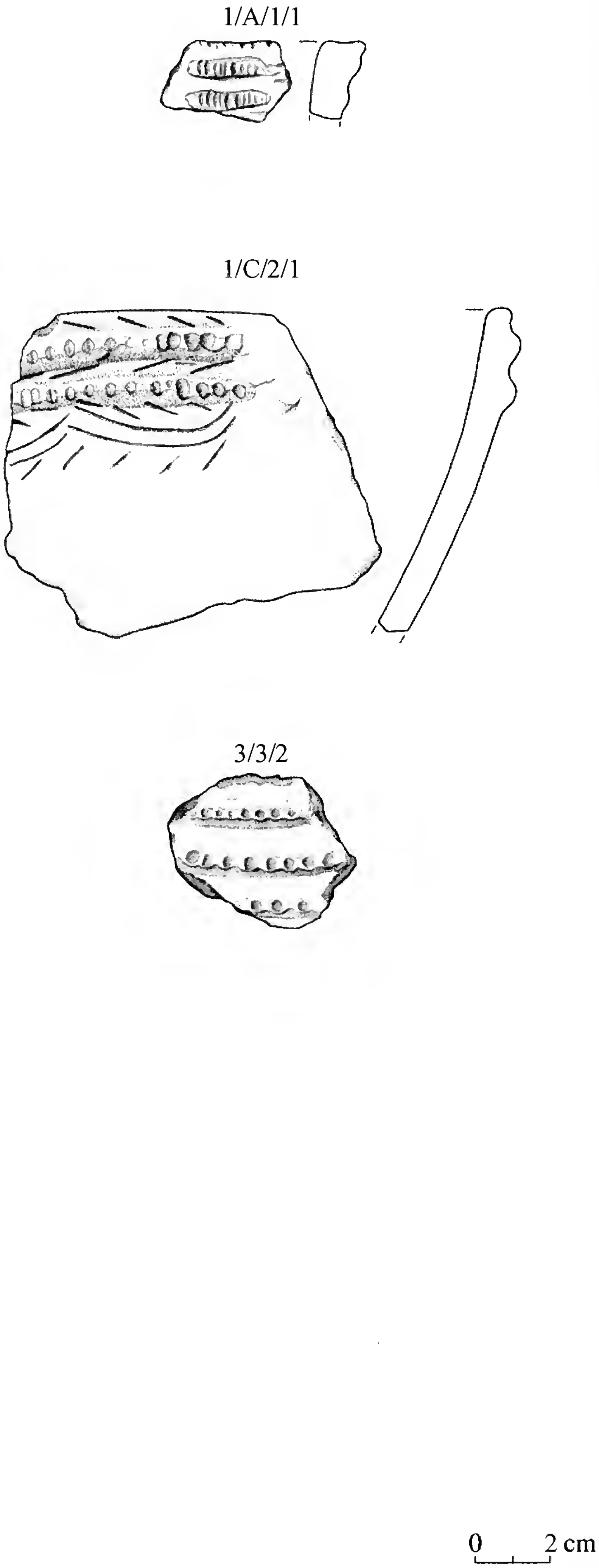


0 2 cm

Appendix 7.1: *Continued.*

	D-52			
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface	2	53	4
Wain	1/A/1/1	1	19	5
	1/A/1/2	4	60	7
Aiser	1/A/2/1	15	122	12
	1/A/2/2	35	406	10
	1/A/2/3	3	171	2
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3	2	98	2
	1/A/4/1		55	
	1/A/4/2	1	57	2
Wain	1/B/1/1	1	32	3
	1/B/1/2	3	68	4
Aiser	1/B/2/1	31	300	10
Aiser/Sumalo	1/B/2/2	23	272	9
Wain	1/C/1/1	1	32	3
	1/C/1/2	2	62	3
Aiser	1/C/2/1	45	285	16
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1	5	180	3
	2/2/2	3	59	5
Nyapin	2/2/3		119	
	2/2/4	3	126	2
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	4	29	14
	3/1/2	3	16	19
Aiser	3/2/1	8	23	35
	3/2/2	1	20	5
	3/2/3	5	72	7
	3/2/4	7	90	8
	3/2/5	3	27	11
	3/3/1	8	36	22
	3/3/2	13	51	25
	3/3/3	10	34	29
	3/3/4	1	11	9

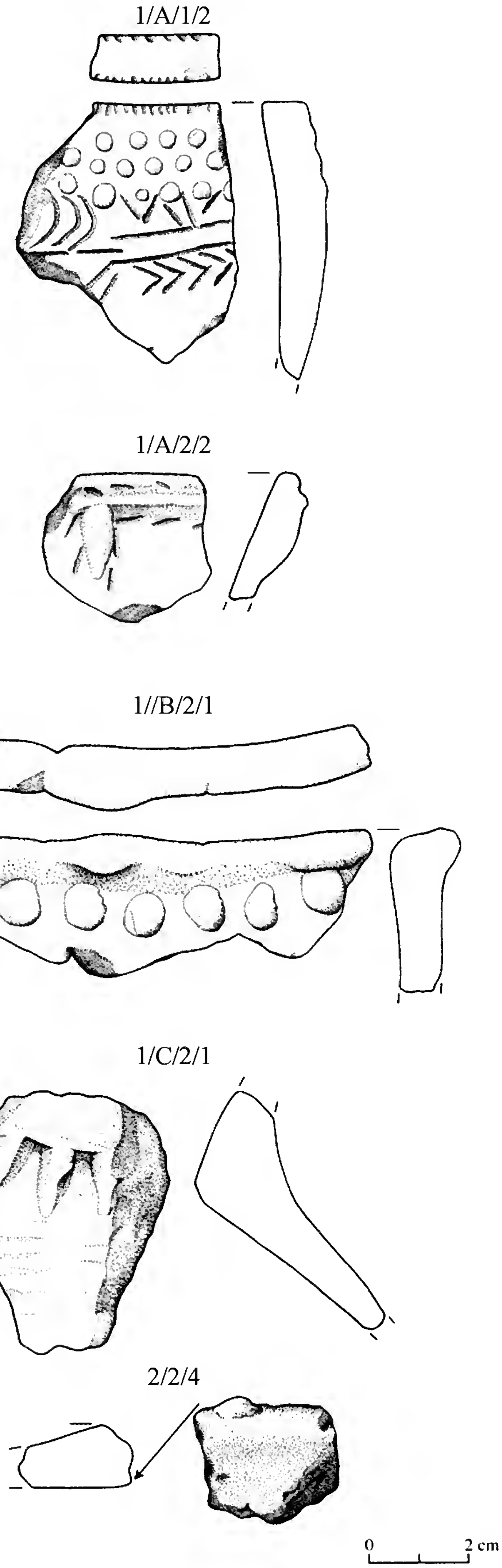
punctate appliqué bands



Appendix 7.1: *Continued.*

	D-53			
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2	2	60	3
Aiser	1/A/2/1	4	122	3
	1/A/2/2	9	406	2
	1/A/2/3	2	171	1
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3	1	98	1
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	1	32	3
	1/B/1/2		68	
Aiser	1/B/2/1	13	300	4
Aiser/Sumalo	1/B/2/2	10	272	4
Wain	1/C/1/1		32	
	1/C/1/2	3	62	5
Aiser	1/C/2/1	11	285	4
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1	1	180	1
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4	3	126	2
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	1	29	4
	3/1/2		16	
Aiser	3/2/1	1	23	4
	3/2/2	2	20	10
	3/2/3	6	72	8
	3/2/4	2	90	2
	3/2/5	3	27	11
	3/3/1	2	36	6
	3/3/2	1	51	2
	3/3/3		34	
	3/3/4		11	

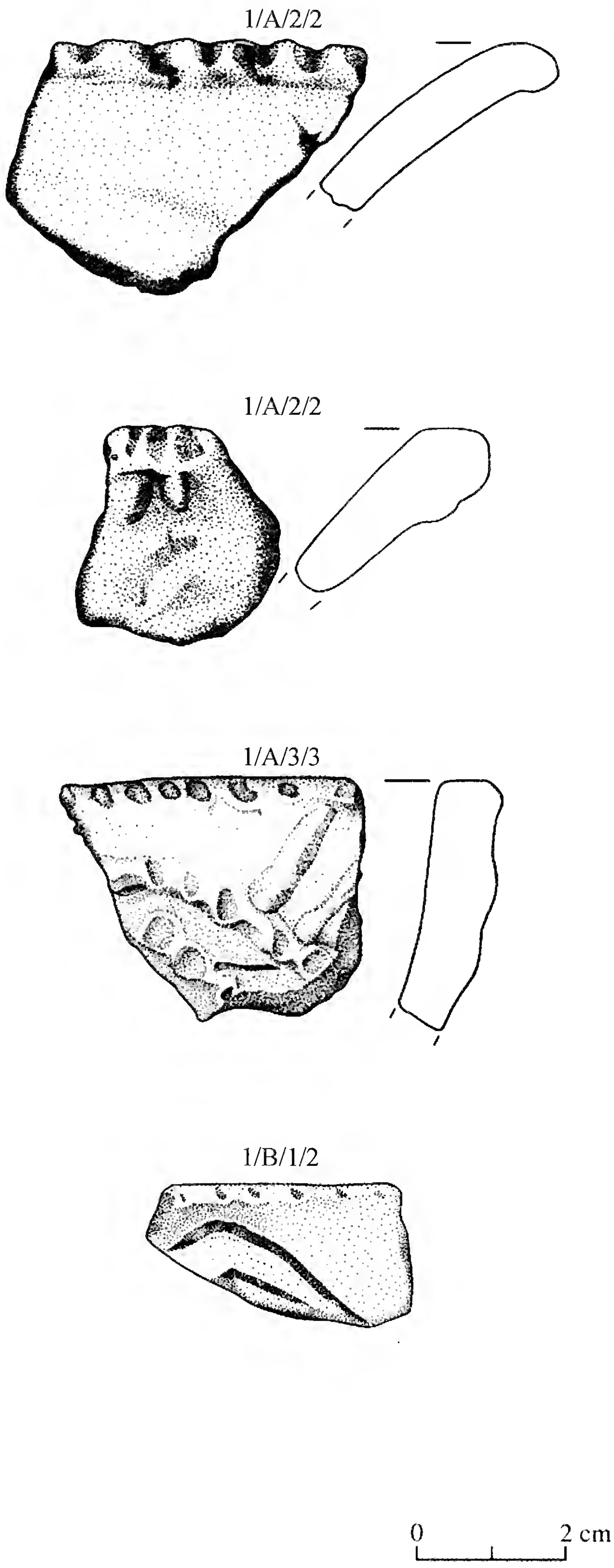
nubbins or vertical appliqué bands



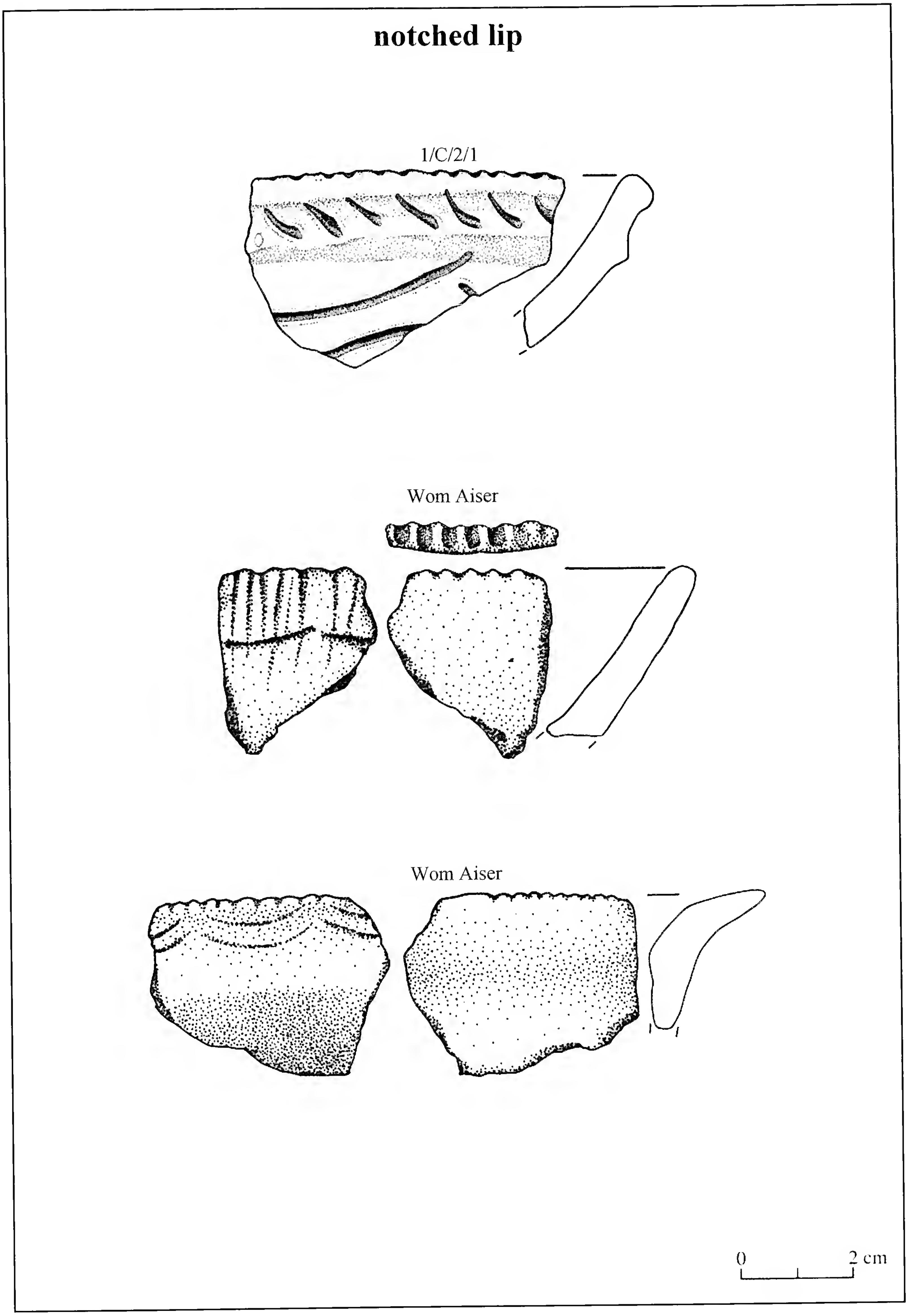
Appendix 7.1: ***Continued.***

	L-11 NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1	2	122	2
	1/A/2/2	26	406	5
	1/A/2/3	2	171	1
Sumalo	1/A/3/1		18	
	1/A/3/2	4	51	8
	1/A/3/3	1	98	1
	1/A/4/1		55	
	1/A/4/2	1	57	2
Wain	1/B/1/1		32	
	1/B/1/2	1	68	1
Aiser	1/B/2/1	14	300	5
Aiser/Sumalo	1/B/2/2	11	272	4
Wain	1/C/1/1		32	
	1/C/1/2	1	62	6
Aiser	1/C/2/1	9	285	3
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2	1	59	2
Nyapin	2/2/3	1	119	1
	2/2/4	1	126	1
	2/2/5	1	34	3
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1	3	23	13
	3/2/2	2	20	10
	3/2/3	1	72	1
	3/2/4	1	90	1
	3/2/5		27	
	3/3/1	2	36	6
	3/3/2	4	51	8
	3/3/3		34	
	3/3/4		11	

notched lip



Appendix 7.1: ***Continued.***

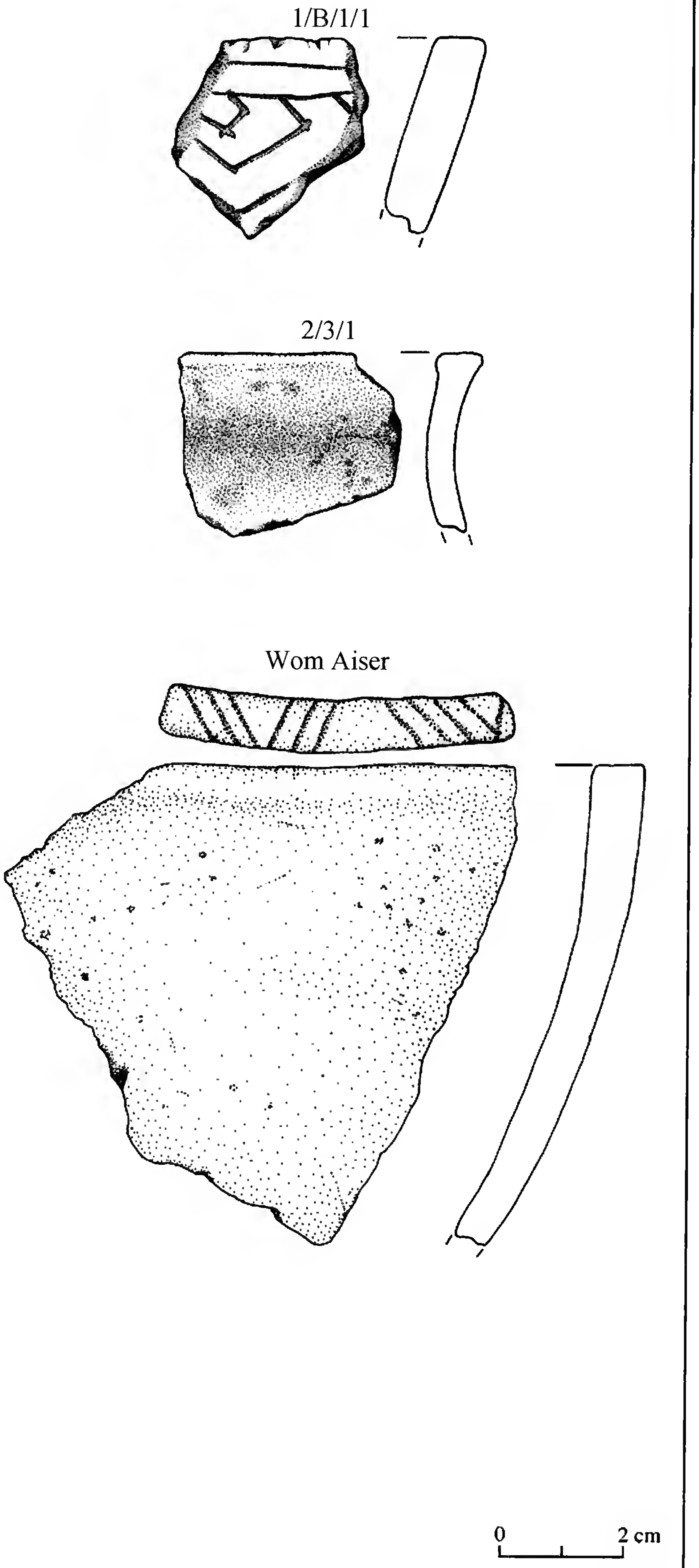


Appendix 7.1: *Continued.*

L-21

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface	6	53	11
Wain	1/A/1/1	5	19	25
	1/A/1/2	9	60	15
Aiser	1/A/2/1	4	122	3
	1/A/2/2	2	406	1
	1/A/2/3	1	171	1
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	10	32	31
	1/B/1/2	12	68	18
Aiser	1/B/2/1	1	300	<1
Aiser/Sumalo	1/B/2/2	1	272	<1
Wain	1/C/1/1	2	32	6
	1/C/1/2	10	62	15
Aiser	1/C/2/1	2	285	1
Wain	2/1/1		10	
	2/1/2	1	34	3
Sumalo	2/2/1	3	180	2
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5	2	34	6
	2/3/1	1	77	1
Wain	3/1/1	4	29	14
	3/1/2	2	16	13
Aiser	3/2/1	1	23	4
	3/2/2	2	20	10
	3/2/3	2	72	3
	3/2/4		90	
	3/2/5		27	
	3/3/1	1	36	3
	3/3/2	1	51	2
	3/3/3	2	34	6
	3/3/4		11	

flat lip

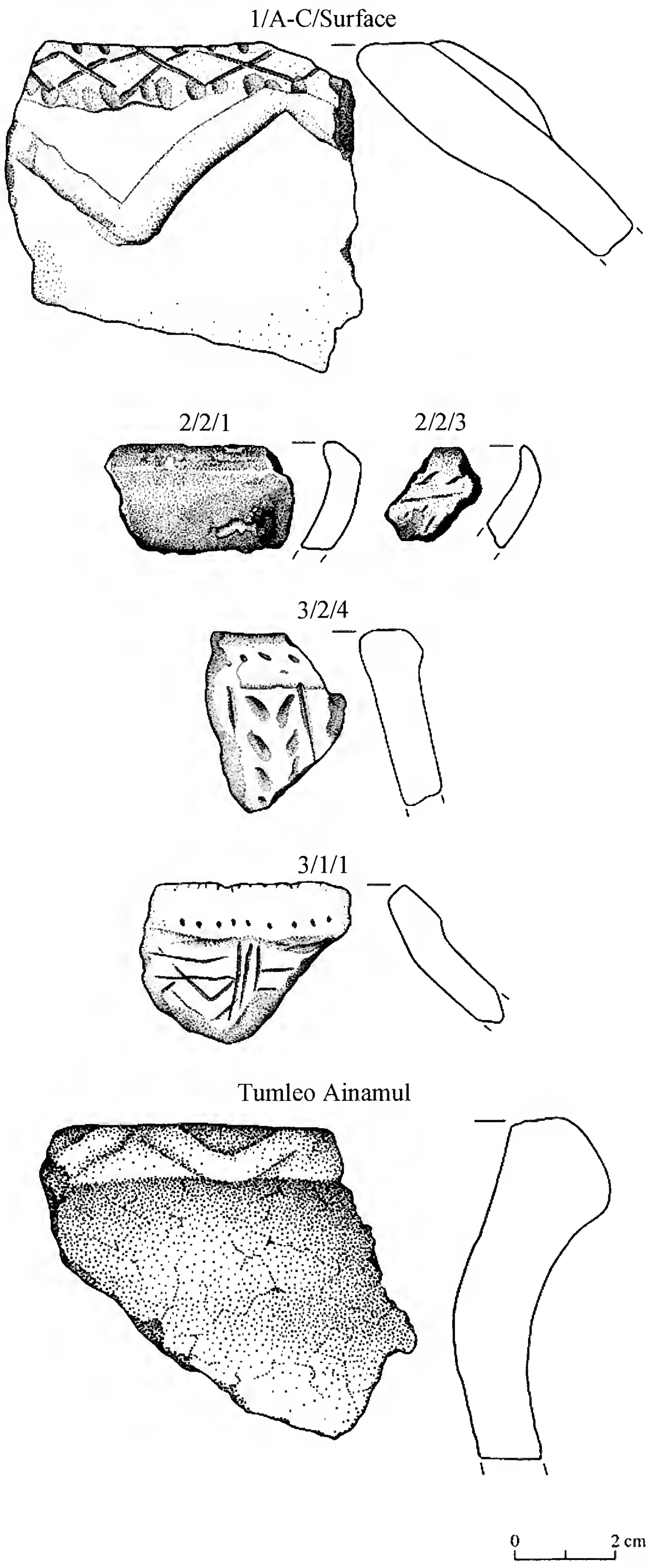


Appendix 7.1: ***Continued.***

L-31

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface	2	53	4
Wain	1/A/1/1	3	19	16
	1/A/1/2	1	60	2
Aiser	1/A/2/1		122	
	1/A/2/2	3	406	<1
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2	1	68	2
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2	2	272	<1
Wain	1/C/1/1		32	
	1/C/1/2	2	62	3
Aiser	1/C/2/1	1	285	<1
Wain	2/1/1		10	
	2/1/2	1	34	3
Sumalo	2/2/1	1	180	<1
	2/2/2		59	
Nyapin	2/2/3	1	119	1
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	1	29	3
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4	1	90	1
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	

beveled lip

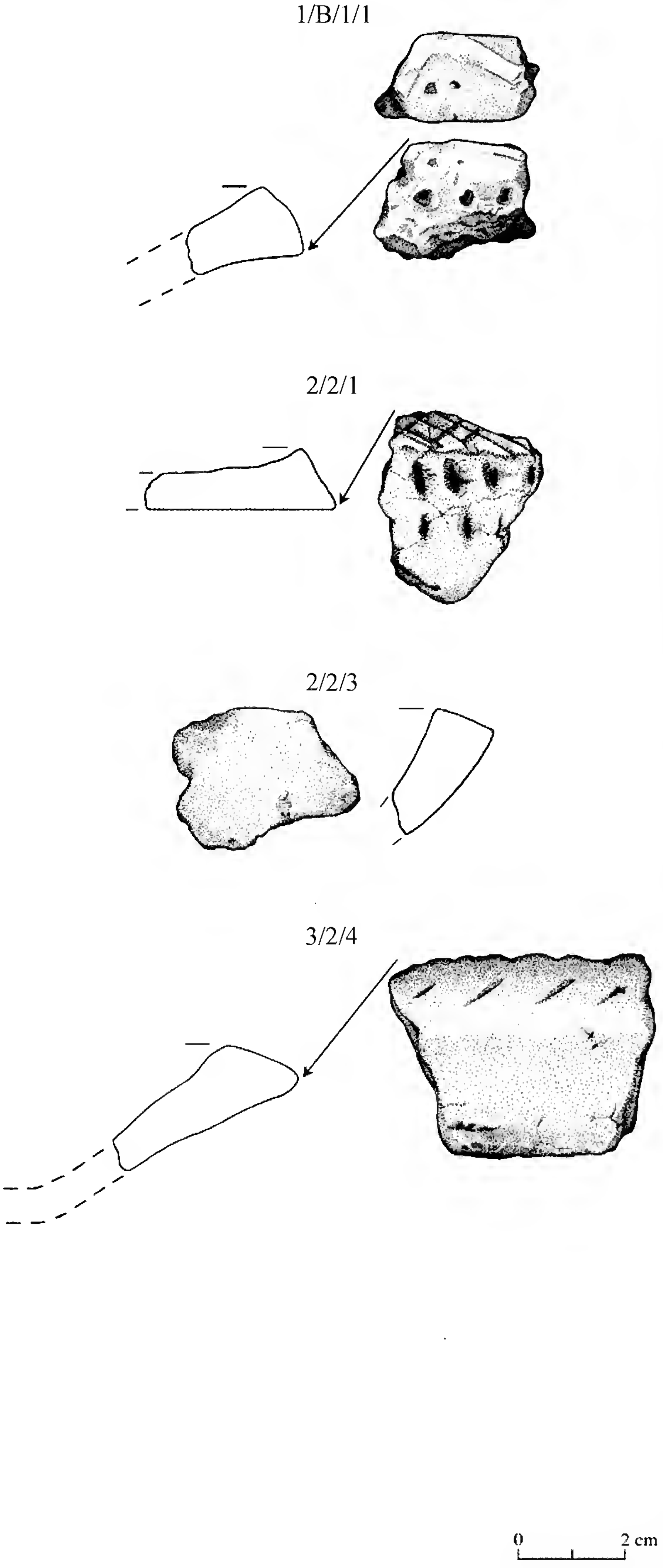


Appendix 7.1: *Continued.*

L-41

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	9	406	2
	1/A/2/3	3	171	2
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	1	32	3
	1/B/1/2		68	
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2	1	272	<1
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1		285	
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1	2	180	1
	2/2/2	3	59	5
Nyapin	2/2/3	2	119	2
	2/2/4	7	126	6
	2/2/5	1	34	3
	2/3/1	4	77	5
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4	2	90	2
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	

triangular lip

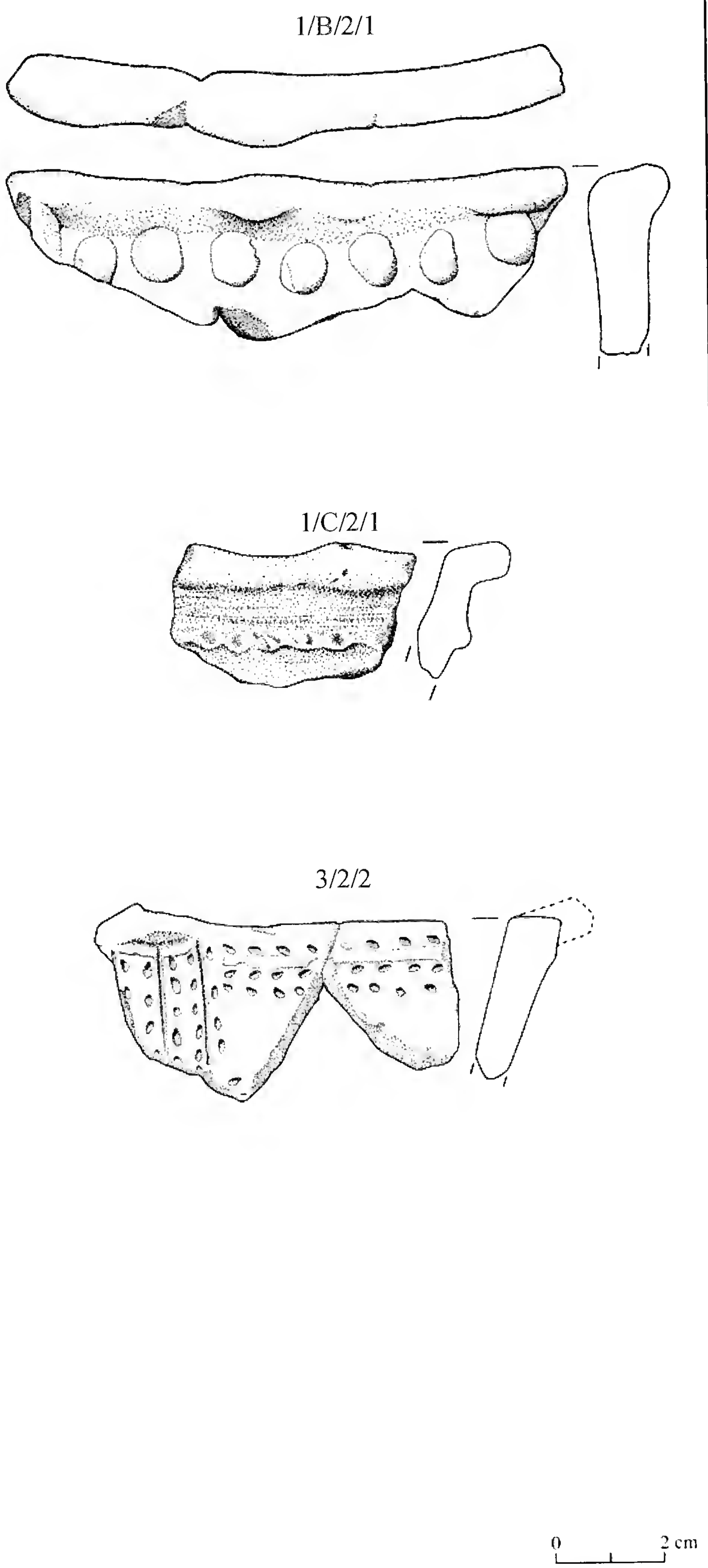


Appendix 7.1: *Continued.*

L-51

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	2	406	<1
	1/A/2/3	1	171	1
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2		68	
Aiser	1/B/2/1	6	300	2
Aiser/Sumalo	1/B/2/2	1	272	<1
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1	3	285	1
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2	1	16	6
Aiser	3/2/1	1	23	4
	3/2/2	1	20	5
	3/2/3		72	
	3/2/4		90	
	3/2/5	1	27	4
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	

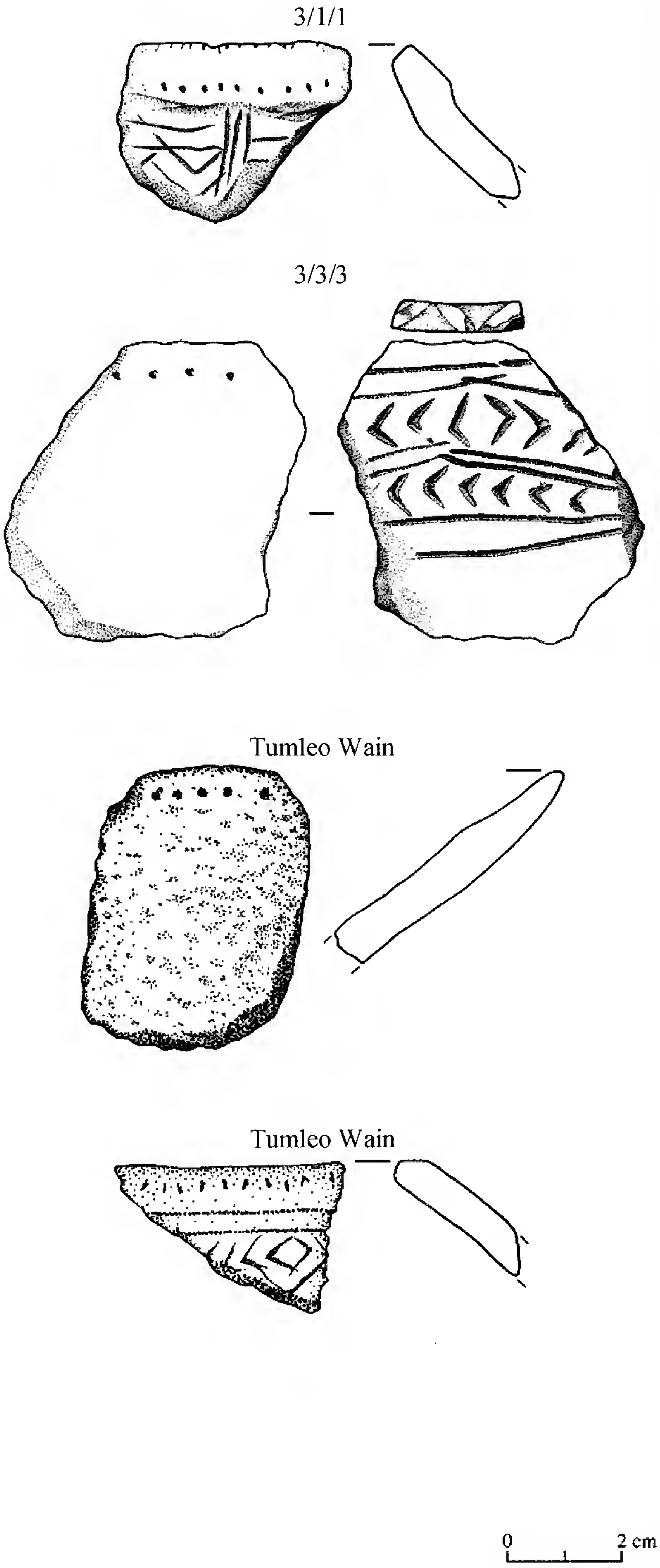
lug(s) at lip edge



Appendix 7.1: ***Continued.***

	T-11			
	NGRP-46	***no.***	***total***	***%***
surface	1/A-C/surface		53	
Wain	1/A/1/1	1	19	5
	1/A/1/2		60	
Aiser	1/A/2/1	3	122	3
	1/A/2/2	4	406	1
	1/A/2/3	3	171	2
Sumalo	1/A/3/1	2	18	11
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	4	32	13
	1/B/1/2	4	68	6
Aiser	14/B/2/1	13	300	4
Aiser/Sumalo	1/B/2/2	18	272	7
Wain	1/C/1/1	2	32	6
	1/C/1/2	5	62	8
Aiser	1/C/2/1	18	285	6
Wain	2/1/1	1	10	10
	2/1/2	1	34	3
Sumalo	2/2/1	3	180	2
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	2	29	7
	3/1/2		16	
Aiser	3/2/1	1	23	4
	3/2/2		20	
	3/2/3	2	72	3
	3/2/4	1	90	1
	3/2/5		27	
	3/3/1		36	
	3/3/2	2	51	4
	3/3/3	3	34	9
	3/3/4	1	11	9

punctations below lip

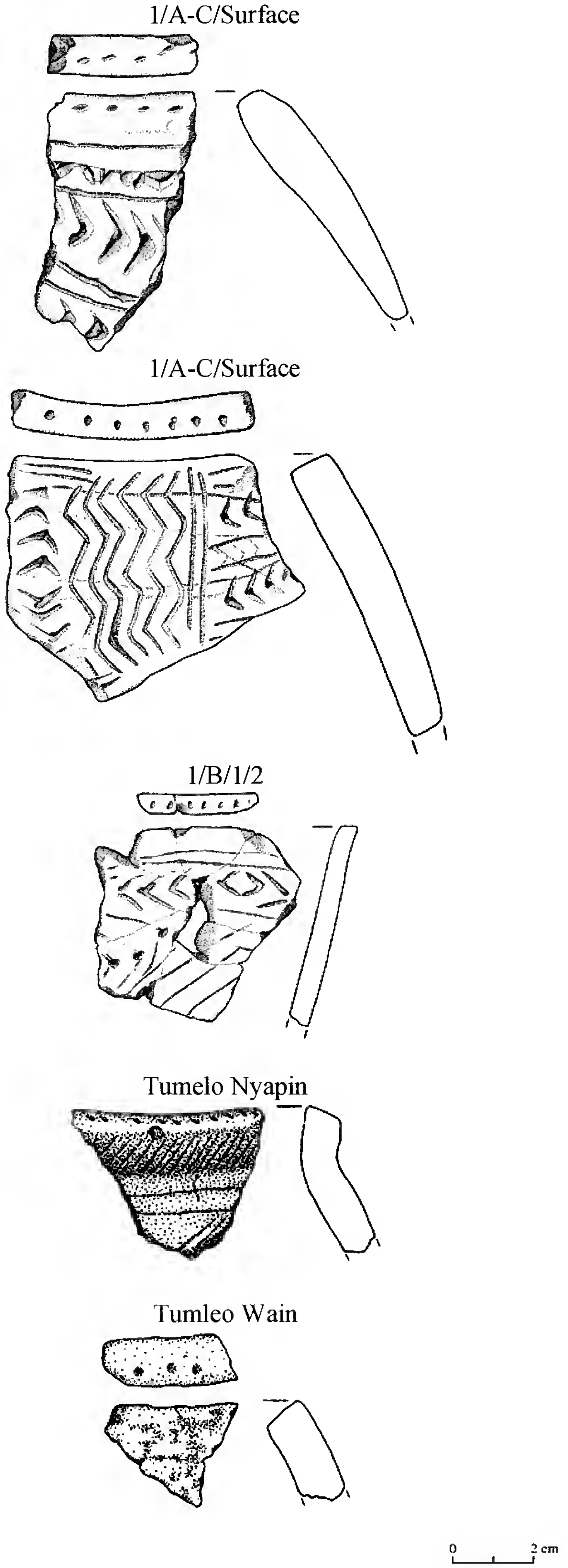


Appendix 7.1: *Continued.*

T-21

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface	2	53	4
Wain	1/A/1/1	1	19	5
	1/A/1/2		60	
Aiser	1/A/2/1	3	122	3
	1/A/2/2	4	406	1
	1/A/2/3	3	171	2
Sumalo	1/A/3/1	2	18	11
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	2	32	6
	1/B/1/2	1	68	2
Aiser	1/B/2/1	1	300	<1
Aiser/Sumalo	1/B/2/2	1	272	<1
Wain	1/C/1/1		32	
	1/C/1/2	2	62	3
Aiser	1/C/2/1		285	
Wain	2/1/1		10	
	2/1/2	1	34	3
Sumalo	2/2/1	1	180	1
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	2	29	7
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1	2	36	6
	3/3/2	1	51	2
	3/3/3	1	34	3
	3/3/4		11	

flat lip with punctations on lip surface



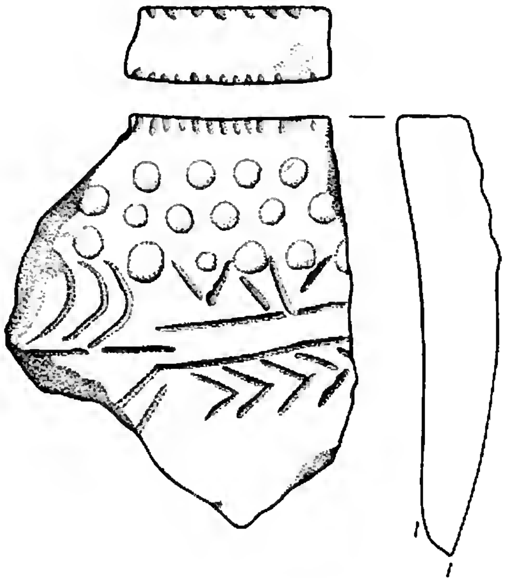
Appendix 7.1: *Continued.*

T-22

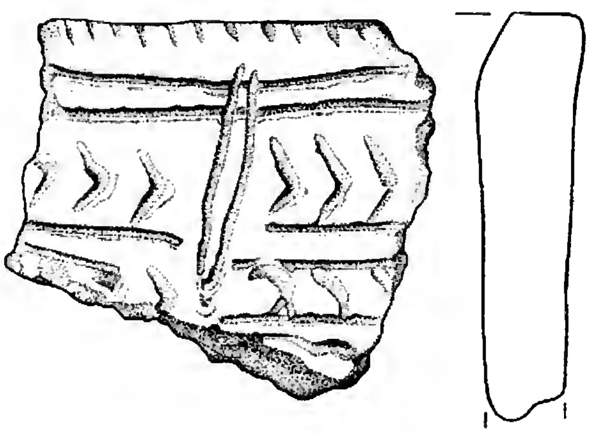
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1	1	19	5
	1/A/1/2	3	60	5
Aiser	1/A/2/1	1	122	1
	1/A/2/2		406	
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	2	32	6
	1/B/1/2	3	68	4
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2	4	272	2
Wain	1/C/1/1		32	
	1/C/1/2	2	62	3
Aiser	1/C/2/1	2	285	1
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	1	29	4
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3	1	34	3
	3/3/4		11	

flat lip with notches on lip edge

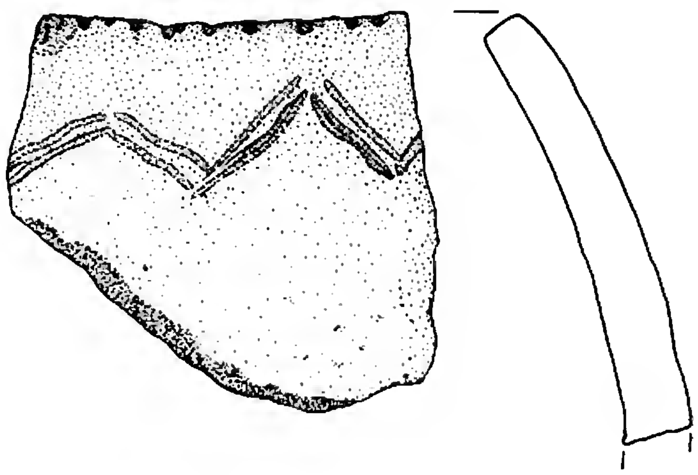
1/A/1/2



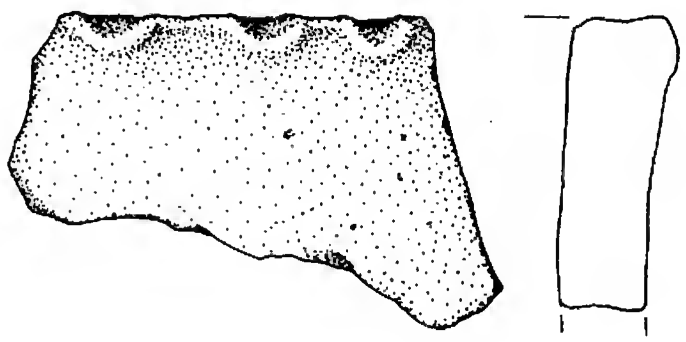
1/B/1/2



Tumleo Ainamul



Tumleo Ainamul

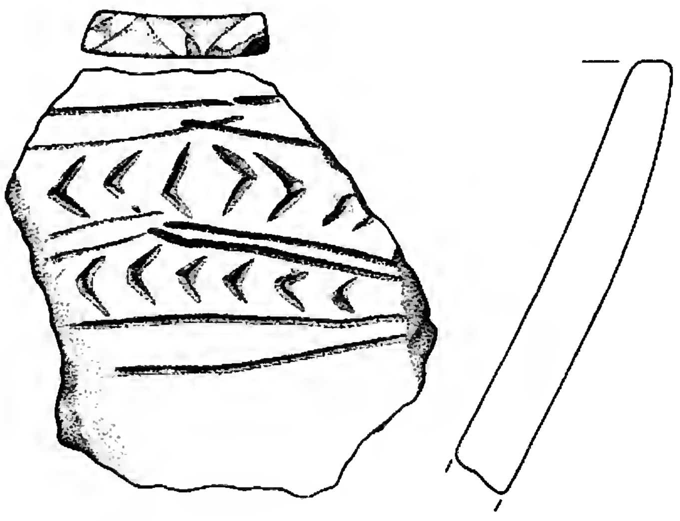


0 2 cm

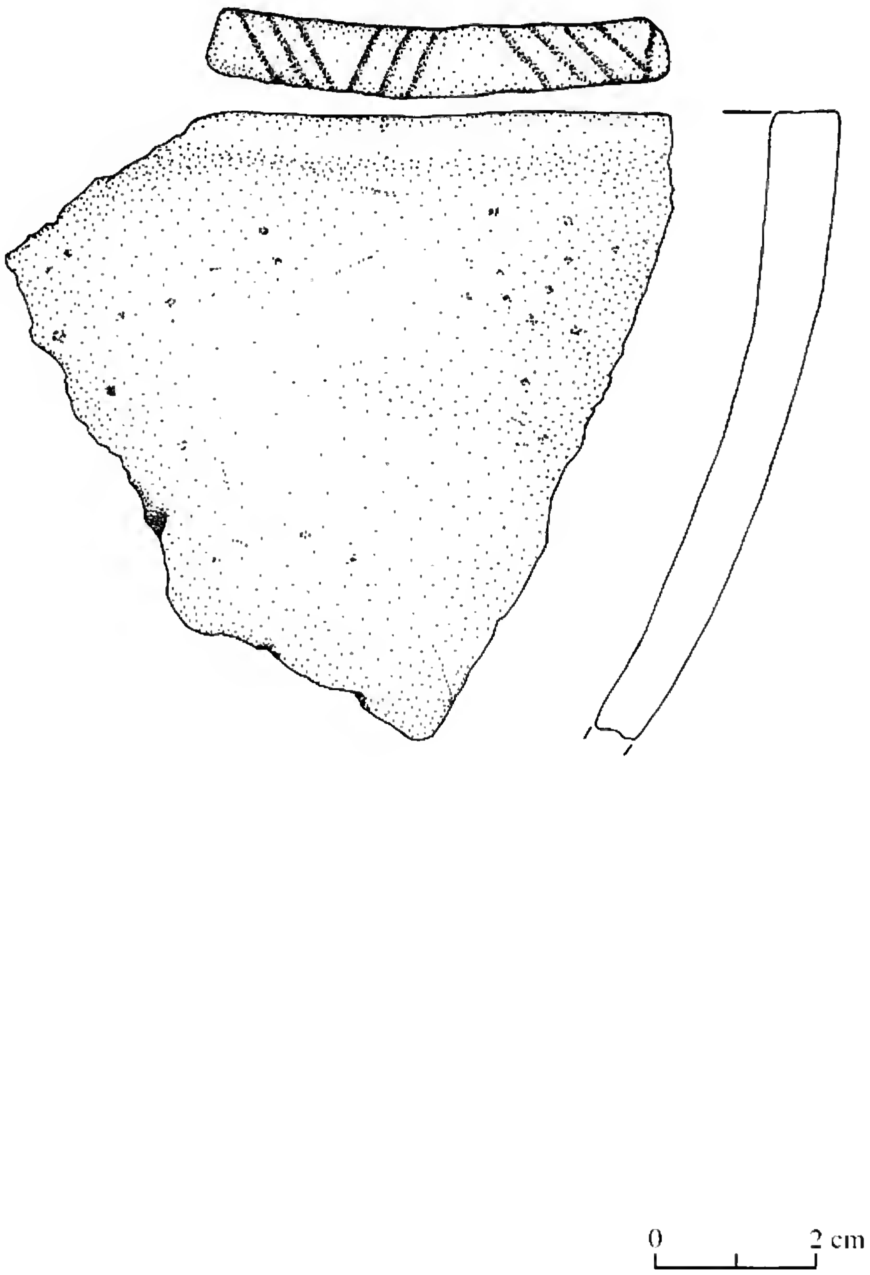
Appendix 7.1: *Continued.*

	T-23				flat lip with appliqué or incised decoration on lip surface
	NGRP-46	*no.*	*total*	*%*	
surface	1/A-C/surface		53		
Wain	1/A/1/1		19		
	1/A/1/2	2	60	3	
Aiser	1/A/2/1		122		
	1/A/2/2		406		
	1/A/2/3	1	171	1	
Sumalo	1/A/3/1		18		
	1/A/3/2		51		
	1/A/3/3		98		
	1/A/4/1		55		
	1/A/4/2		57		
Wain	1/B/1/1	1	32	3	
	1/B/1/2	1	68	2	
Aiser	1/B/2/1		300		
Aiser/Sumalo	1/B/2/2		272		
Wain	1/C/1/1		32		
	1/C/1/2	2	62	5	
Aiser	1/C/2/1	2	285	1	
Wain	2/1/1		10		
	2/1/2		34		
Sumalo	2/2/1		180		
	2/2/2		59		
Nyapin	2/2/3		119		
	2/2/4		126		
	2/2/5		34		
	2/3/1		77		
Wain	3/1/1		29		
	3/1/2	1	16	6	
Aiser	3/2/1		23		
	3/2/2		20		
	3/2/3		72		
	3/2/4		90		
	3/2/5		27		
	3/3/1		36		
	3/3/2		51		
	3/3/3	1	34	3	
	3/3/4		11		

3/3/3



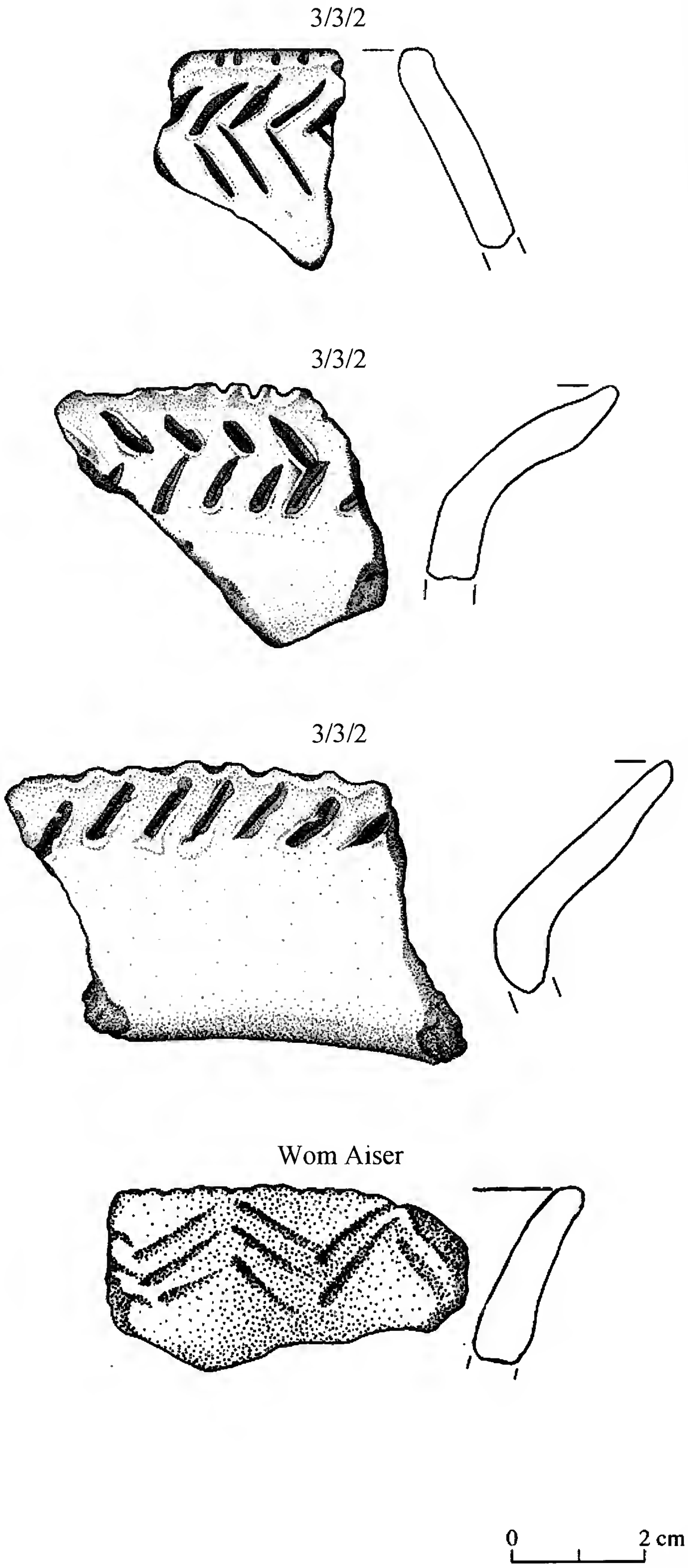
Wom Aiser



Appendix 7.1: *Continued.*

	T-31			
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	11	406	3
	1/A/2/3	1	171	1
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2		68	
Aiser	1/B/2/1	11	300	4
Aiser/Sumalo	1/B/2/2	2	272	1
Wain	1/C/1/1		32	
	1/C/1/2	1	62	1
Aiser	1/C/2/1	1	285	<1
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1	1	23	4
	3/2/2	1	20	5
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2	3	51	6
	3/3/3		34	
	3/3/4		11	

notched lip with diagonal lines or punctations below the lip edge



Appendix 7.1: ***Continued.***

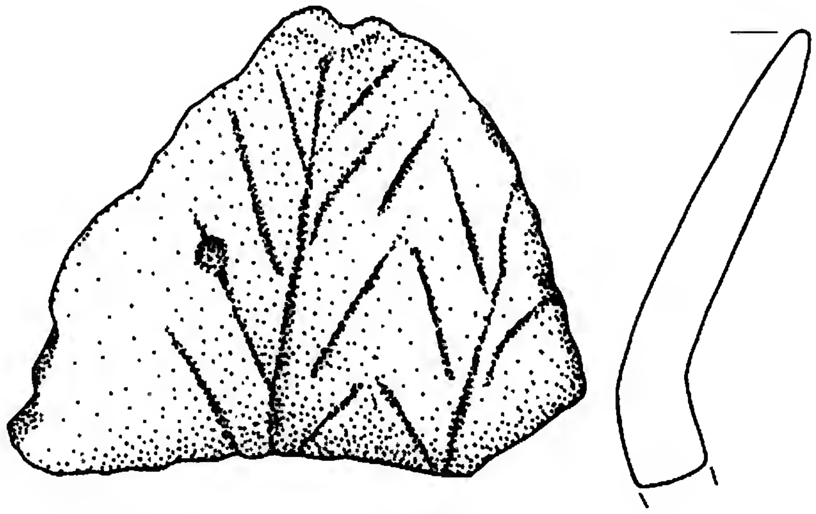
T-41

"plant" – herringbone incisions separated by an incised line

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1	4	122	3
	1/A/2/2	8	406	2
	1/A/2/3	2	171	1
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2		68	
Aiser	1/B/2/1	5	300	2
Aiser/Sumalo	1/B/2/2	7	272	3
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1	11	285	4
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3	1	72	1
	3/2/4	1	90	1
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3	1	34	3
	3/3/4		11	

1/A/2/2

Wom Aiser

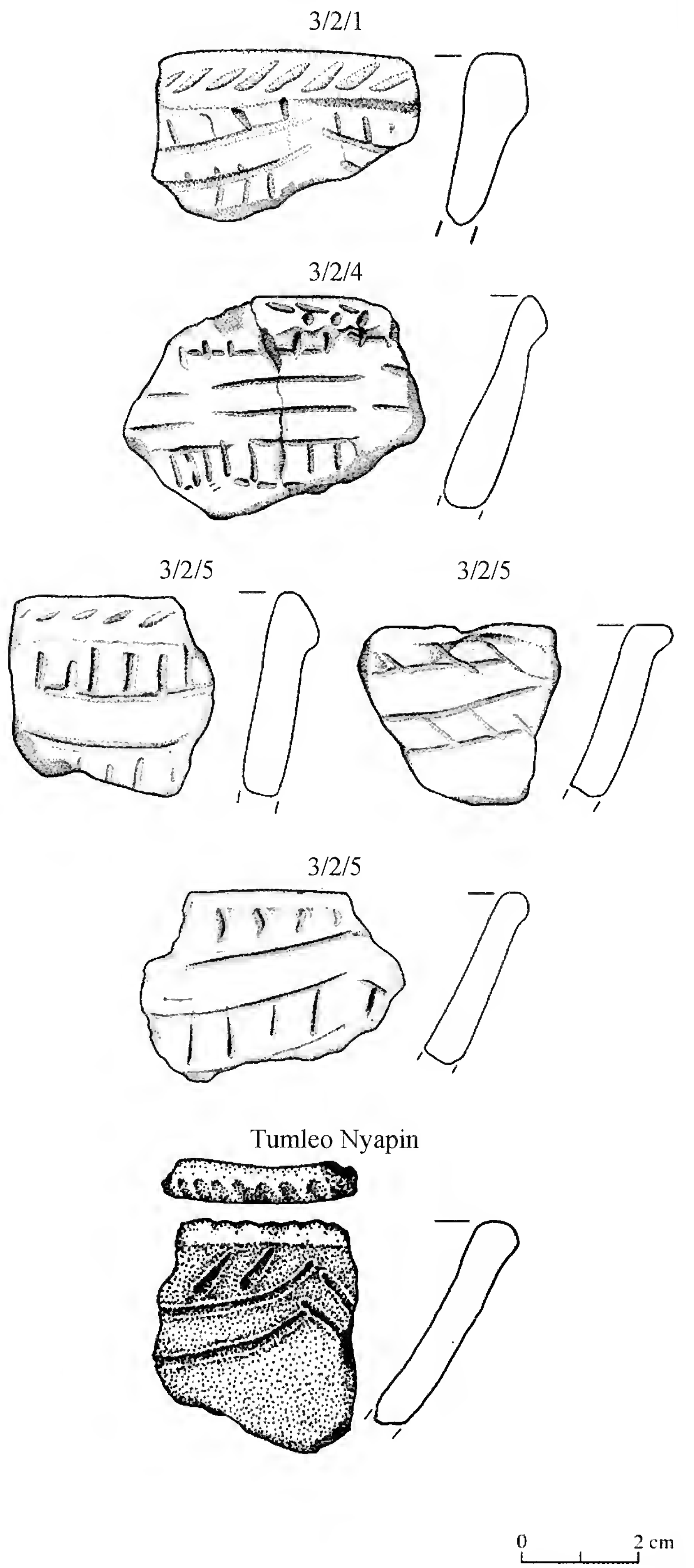


0 2 cm

Appendix 7.1: *Continued.*

	T-61			
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1	2	122	2
	1/A/2/2	6	406	2
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	2	32	6
	1/B/1/2		68	
Aiser	1/B/2/1	13	300	4
Aiser/Sumalo	1/B/2/2	7	272	3
Wain	1/C/1/1		32	
	1/C/1/2	1	62	2
Aiser	1/C/2/1	1	285	<1
Wain	2/1/1		10	
	2/1/2	1	34	3
Sumalo	2/2/1	1	180	1
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1	2	23	9
	3/2/2	2	20	10
	3/2/3	2	72	3
	3/2/4	7	90	8
	3/2/5	7	27	26
	3/3/1	2	36	6
	3/3/2	1	51	2
	3/3/3	4	34	12
	3/3/4		11	

two or more incised lines with one or more lateral row(s) of diagonal punctations or incisions



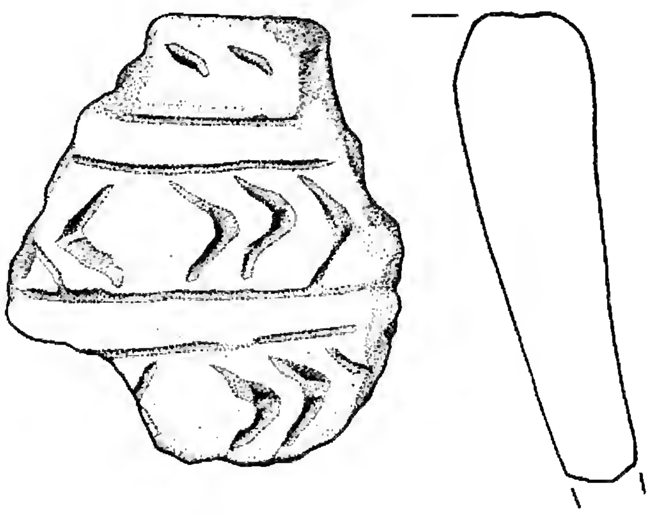
Appendix 7.1: ***Continued.***

T-62

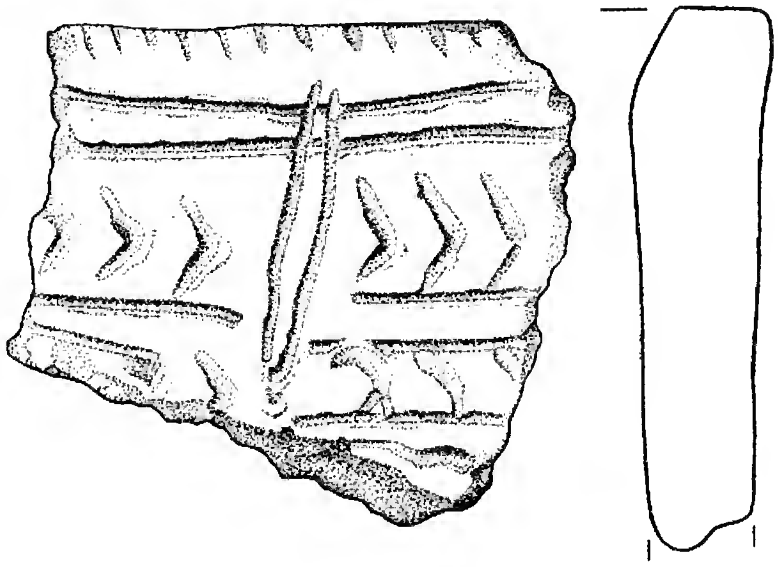
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1	1	19	5
	1/A/1/2	2	60	3
Aiser	1/A/2/1	1	122	1
	1/A/2/2		406	
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	2	32	6
	1/B/1/2	12	68	18
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2		272	
Wain	1/C/1/1	1	32	3
	1/C/1/2	2	62	3
Aiser	1/C/2/1	1	285	<1
Wain	2/1/1		10	
	2/1/2	3	34	9
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	1	29	4
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	

incised lines bordering herringbone punctations

1/A/2/1



1/B/1/2



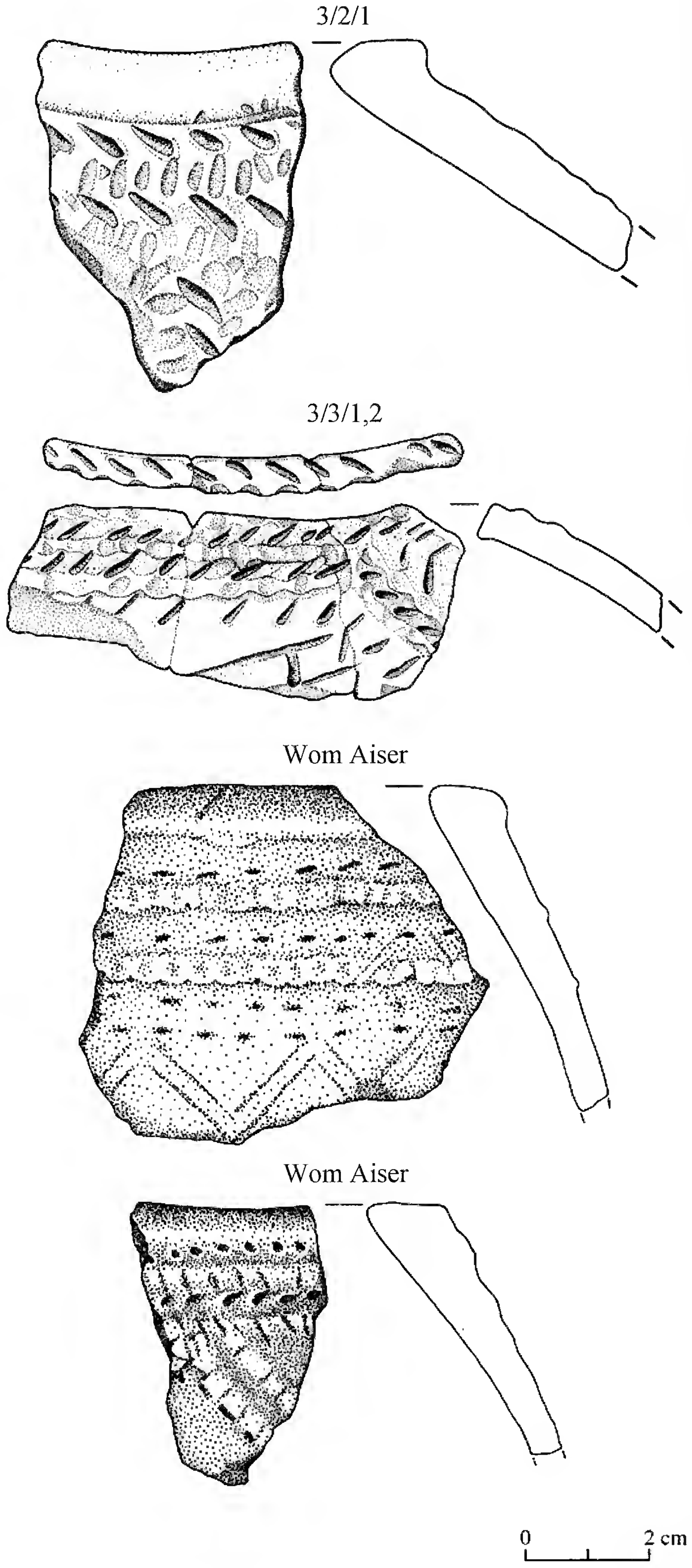
0 2 cm

Appendix 7.1: ***Continued.***

T-71

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1	6	122	5
	1/A/2/2	39	406	10
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3	1	98	1
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	1	32	3
	1/B/1/2	2	68	3
Aiser	1/B/2/1	23	300	8
Aiser/Sumalo	1/B/2/2	20	272	7
Wain	1/C/1/1		32	
	1/C/1/2	1	62	2
Aiser	1/C/2/1	29	285	10
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	2	29	7
	3/1/2	3	16	19
Aiser	3/2/1	4	23	17
	3/2/2	2	20	10
	3/2/3	7	72	10
	3/2/4	5	90	6
	3/2/5	2	27	7
	3/3/1	6	36	17
	3/3/2	6	51	12
	3/3/3	4	34	12
	3/3/4		11	

appliqué punctate bands with one or more row(s) of diagonal incisions or punctations

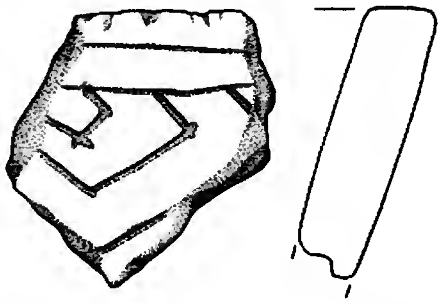


Appendix 7.1: *Continued.*

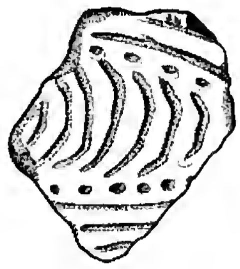
	T-81 NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1	2	19	11
	1/A/1/2		60	
Aiser	1/A/2/1	1	122	1
	1/A/2/2		406	
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	1	32	3
	1/B/1/2	1	68	< 1
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2		272	
Wain	1/C/1/1	1	32	3
	1/C/1/2	1	62	2
Aiser	1/C/2/1		285	
Wain	2/1/1		10	
	2/1/2	1	34	3
Sumalo	2/2/1	1	180	1
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	

"bulls-eye" (multiple incised linear or curvilinear concentric lines)

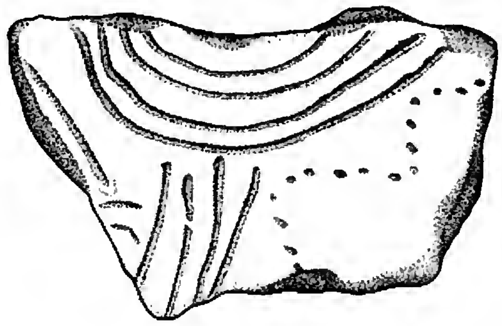
1/B/1/1



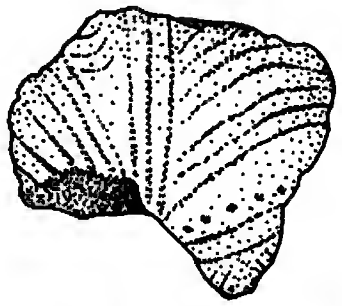
1/B/1/2



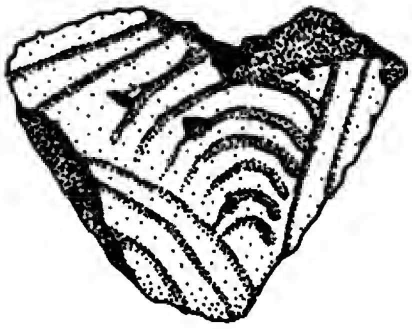
1/C/1/1



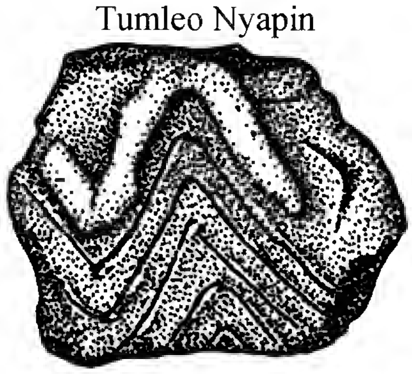
Tumleo Nyapin



Tumleo Nyapin



Tumleo Nyapin

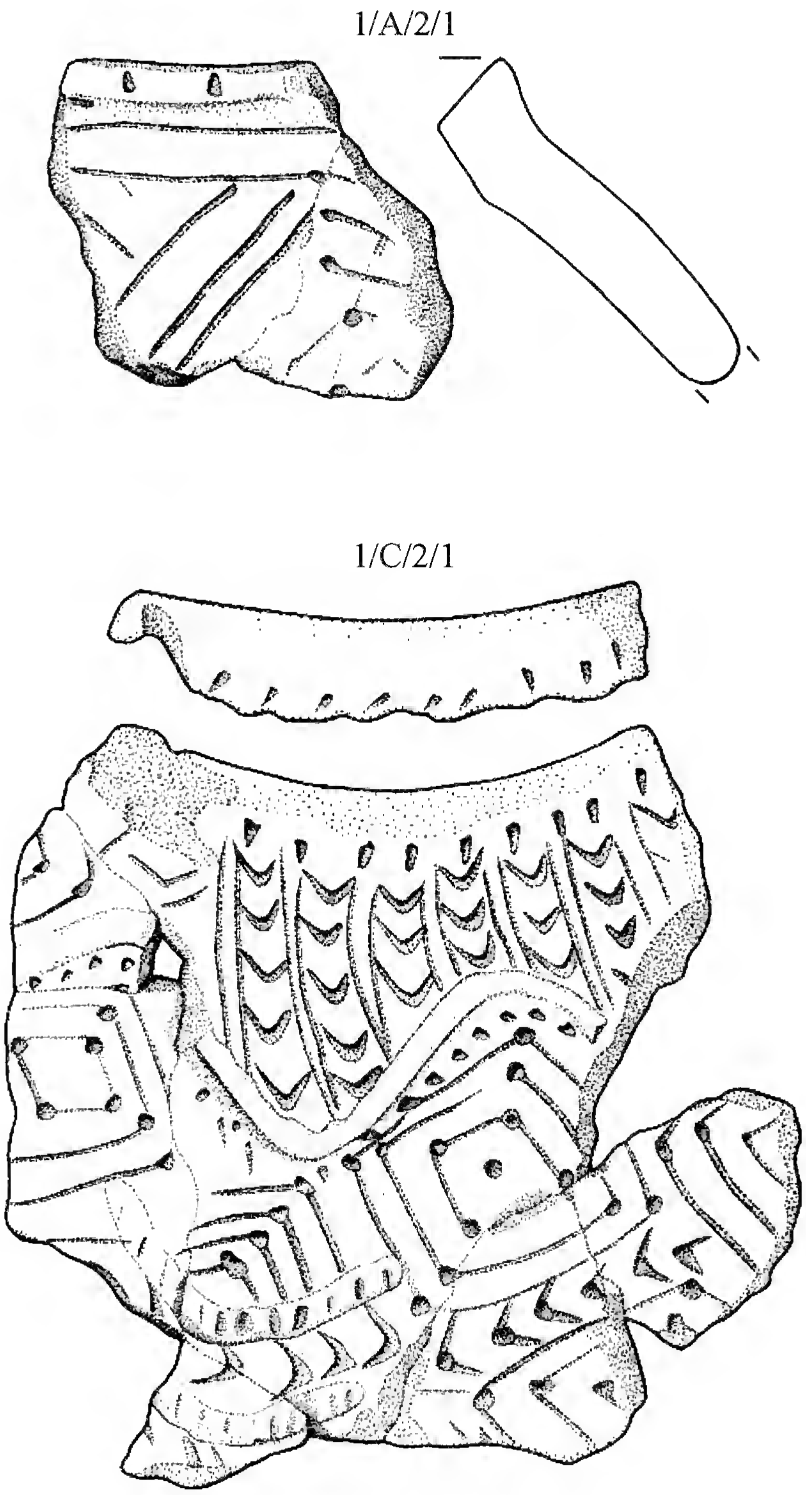


0 2 cm

Appendix 7.1: *Continued.*

	T-82			
	NGRP-46	***no.***	***total***	***%***
surface	1/A-C/surface		53	
Wain	1/A/1/1	2	19	11
	1/A/1/2	1	60	2
Aiser	1/A/2/1	3	122	3
	1/A/2/2		406	
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	4	32	13
	1/B/1/2	3	68	4
Aiser	4			
Aiser/Sumalo	1/B/2/1		300	
	1/B/2/2		272	
Wain	1/C/1/1	1	32	3
Aiser	1/C/1/2		62	
	1/C/2/1	1	285	<1
Wain	2/1/1		10	
Sumalo	2/1/2		34	
	2/2/1		180	
Nyapin	2/2/2		59	
	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	

"bulls-eye" with guide marks



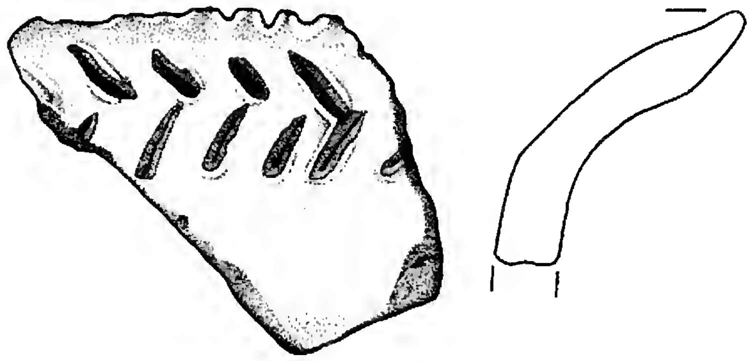
Appendix 7.1: ***Continued.***

M-11

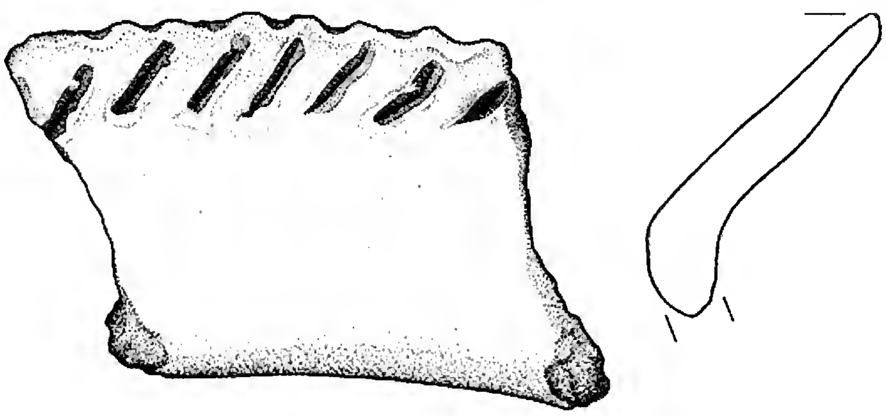
notched everted rim with diagonal lines or punctations

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1	1	122	1
	1/A/2/2	21	406	<1
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2		68	
Aiser	1/B/2/1	1	300	<1
Aiser/Sumalo	1/B/2/2	3	272	1
Wain	1/C/1/1		32	
	1/C/1/2	1	62	2
Aiser	1/C/2/1		285	
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3	1	72	1
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2	3	51	6
	3/3/3		34	
	3/3/4		11	

3/3/2



3/3/2



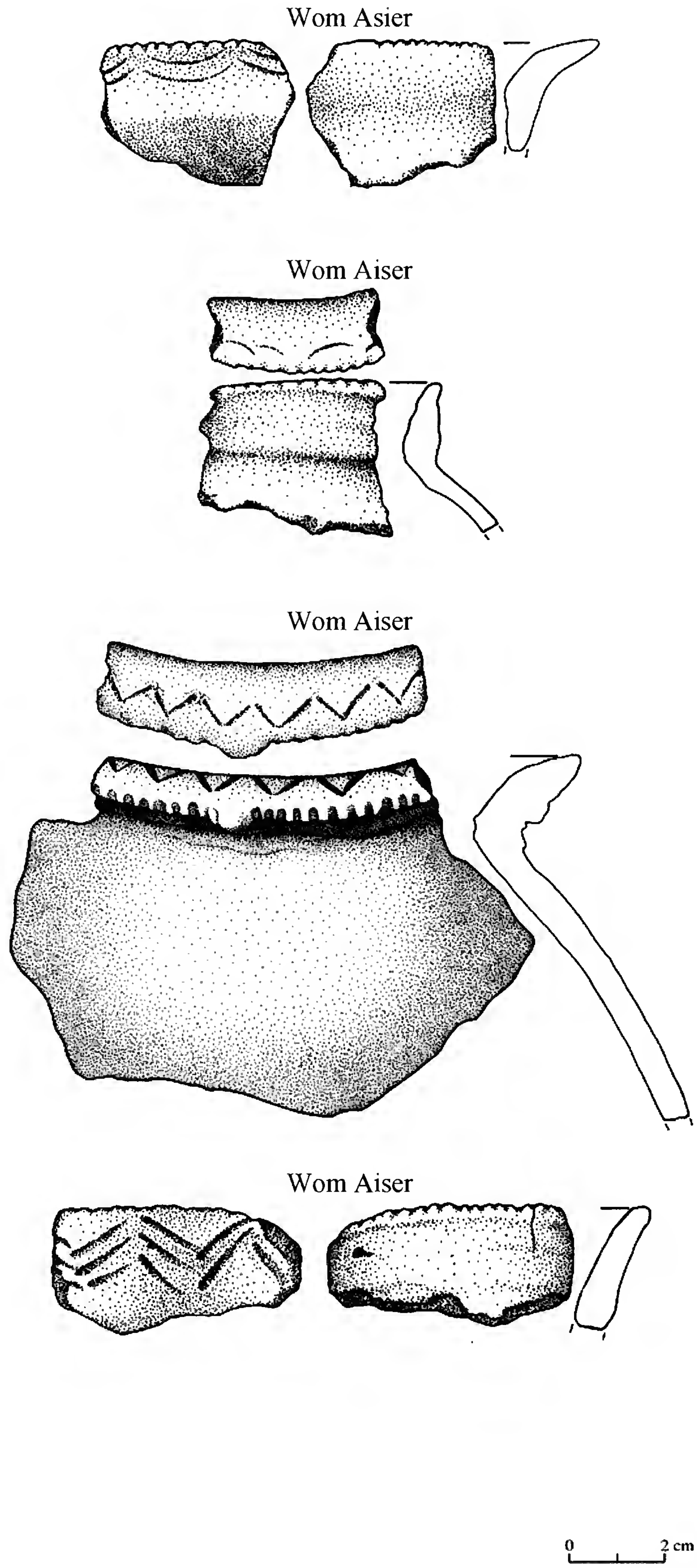
0 2 cm

Appendix 7.1: *Continued.*

M-12

notched everted rim with linear or curvilinear hanging incised lines

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	2	406	<1
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2		68	
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2		272	
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1		285	
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1	3	23	13
	3/2/2	1	20	5
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	



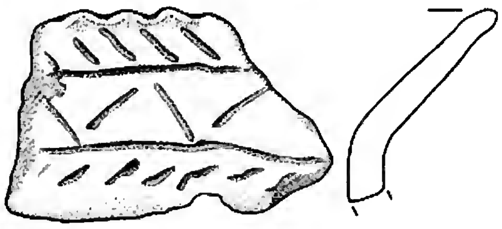
Appendix 7.1: *Continued.*

M-13

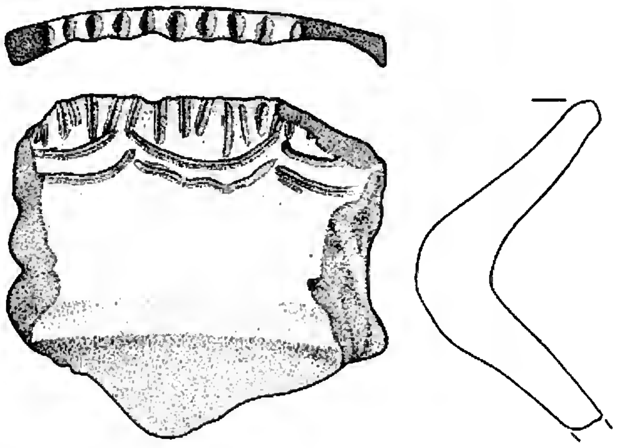
notched everted rim with linear or curvilinear hanging incised lines & vertical or diagonal incised lines below the lip edge

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1	1	122	1
	1/A/2/2		406	
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2		68	
Aiser	1/B/2/1	1	300	<1
Aiser/Sumalo	1/B/2/2	1	272	<1
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1		285	
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2	1	20	5
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	

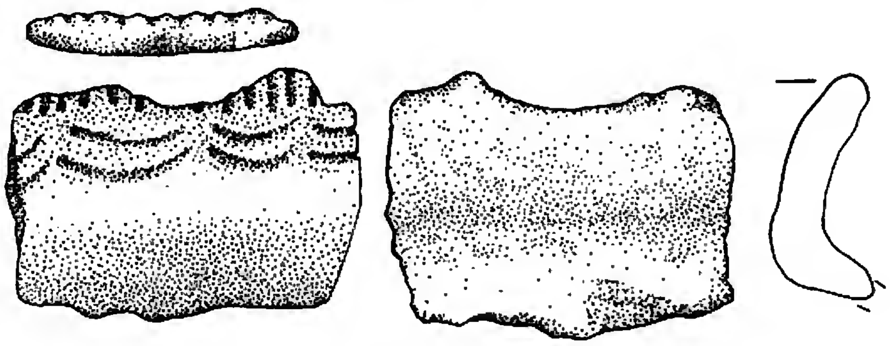
1/B/2/2



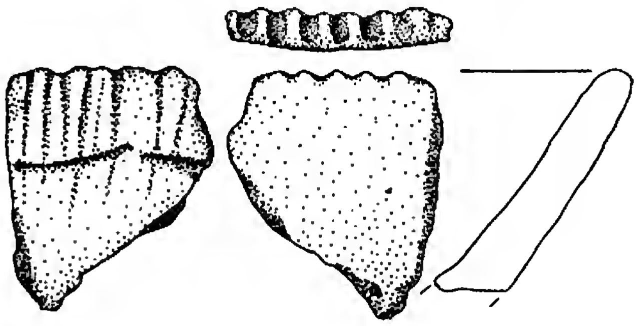
3/2/2

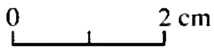


Wom Aiser



Wom Aiser





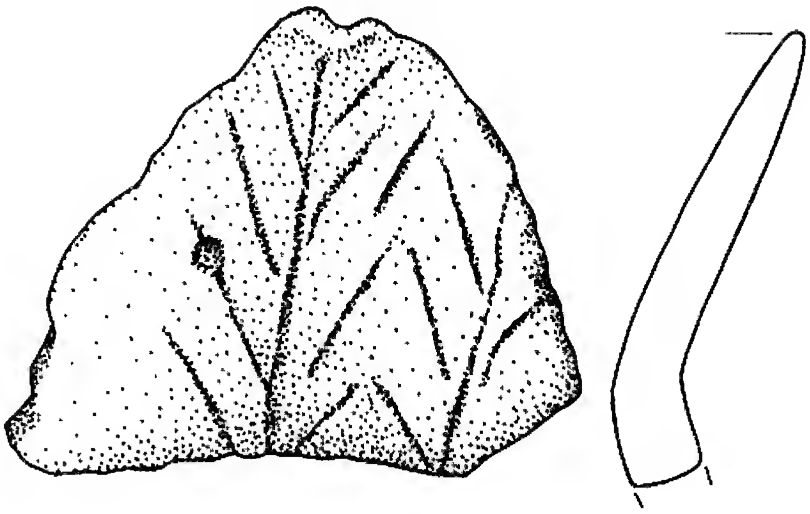
Appendix 7.1: *Continued.*

	M-14			
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	1	406	<1
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2		68	
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2		272	
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1	2	285	1
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	

notched everted rim with incised "plant" design on interior surface

1/A/2/2

Wom Aiser



Appendix 7.1: *Continued.*

	M-20				zoned fine-line incised "face"
	NGRP-46	*no.*	*total*	*%*	
surface	1/A-C/surface		53		
Wain	1/A/1/1		19		
	1/A/1/2		60		
Aiser	1/A/2/1		122		
	1/A/2/2		406		
	1/A/2/3		171		
Sumalo	1/A/3/1		18		
	1/A/3/2		51		
	1/A/3/3		98		
	1/A/4/1		55		
	1/A/4/2		57		
Wain	1/B/1/1		32		
	1/B/1/2		68		
Aiser	1/B/2/1		300		
Aiser/Sumalo	1/B/2/2		272		
Wain	1/C/1/1		32		
	1/C/1/2		62		
Aiser	1/C/2/1		285		
Wain	2/1/1		10		
	2/1/2		34		
Sumalo	2/2/1		180		
	2/2/2		59		
Nyapin	2/2/3		119		
	2/2/4	1	126	1	
	2/2/5		34		
	2/3/1		77		
Wain	3/1/1		29		
	3/1/2		16		
Aiser	3/2/1		23		
	3/2/2		20		
	3/2/3		72		
	3/2/4		90		
	3/2/5		27		
	3/3/1		36		
	3/3/2		51		
	3/3/3		34		
	3/3/4		11		

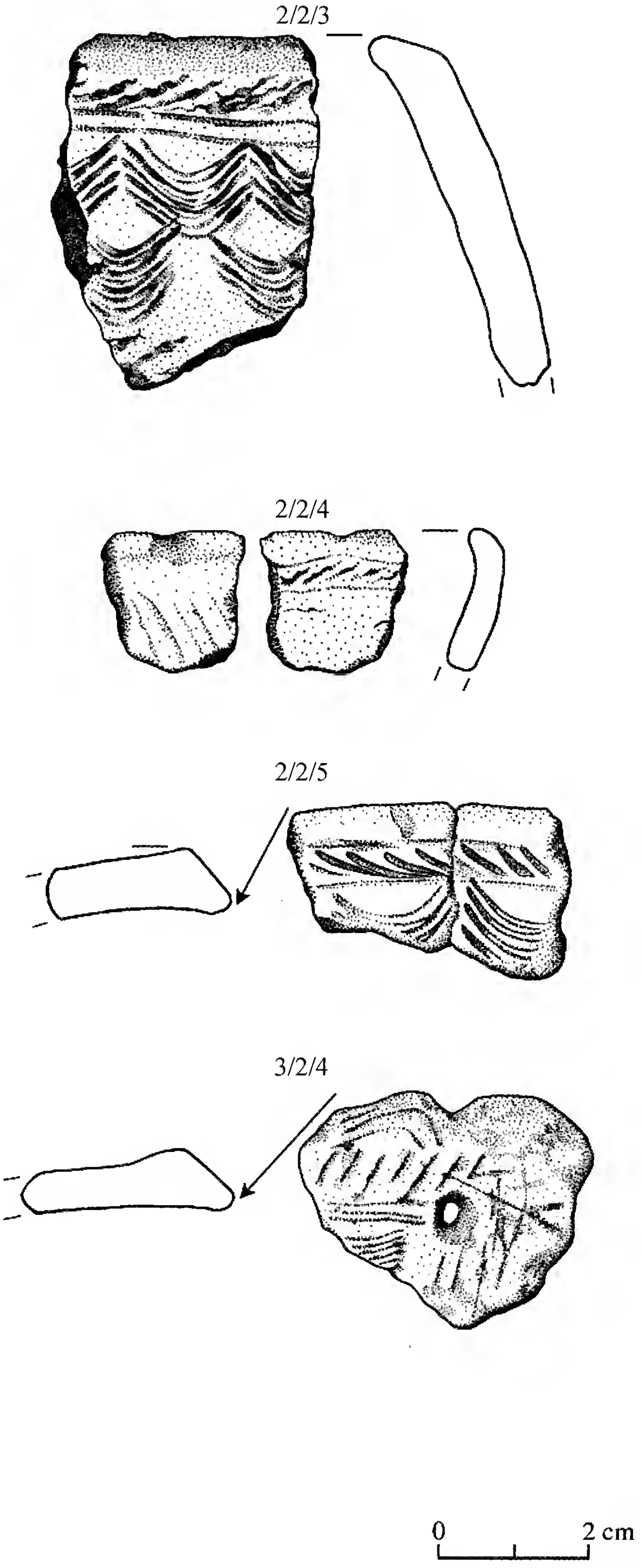
2/2/4

Appendix 7.1: *Continued.*

M-21

zoned fine-line scored "face"

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	1	406	<1
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2		68	
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2		272	
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1		285	
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3	3	119	3
	2/2/4	3	126	2
	2/2/5	1	34	3
	2/3/1	1	77	1
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4	1	90	1
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	



Appendix 7.1: *Continued.*

M-22

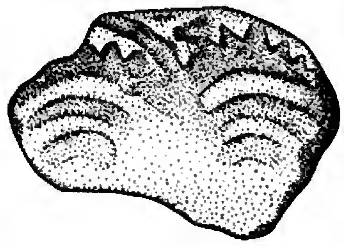
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	1	406	<1
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2	1	57	2
Wain	1/B/1/1		32	
	1/B/1/2	1	68	2
Aiser	1/B/2/1	1	300	<1
Aiser/Sumalo	1/B/2/2	4	272	2
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1	4	285	1
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2	1	59	2
Nyapin	2/2/3	1	119	1
	2/2/4	1	126	1
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2	1	20	5
	3/2/3	1	72	1
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3	1	34	3
	3/3/4		11	

broad-tooth scored and impressed "face"

1/A/2/2

1/A/4/2

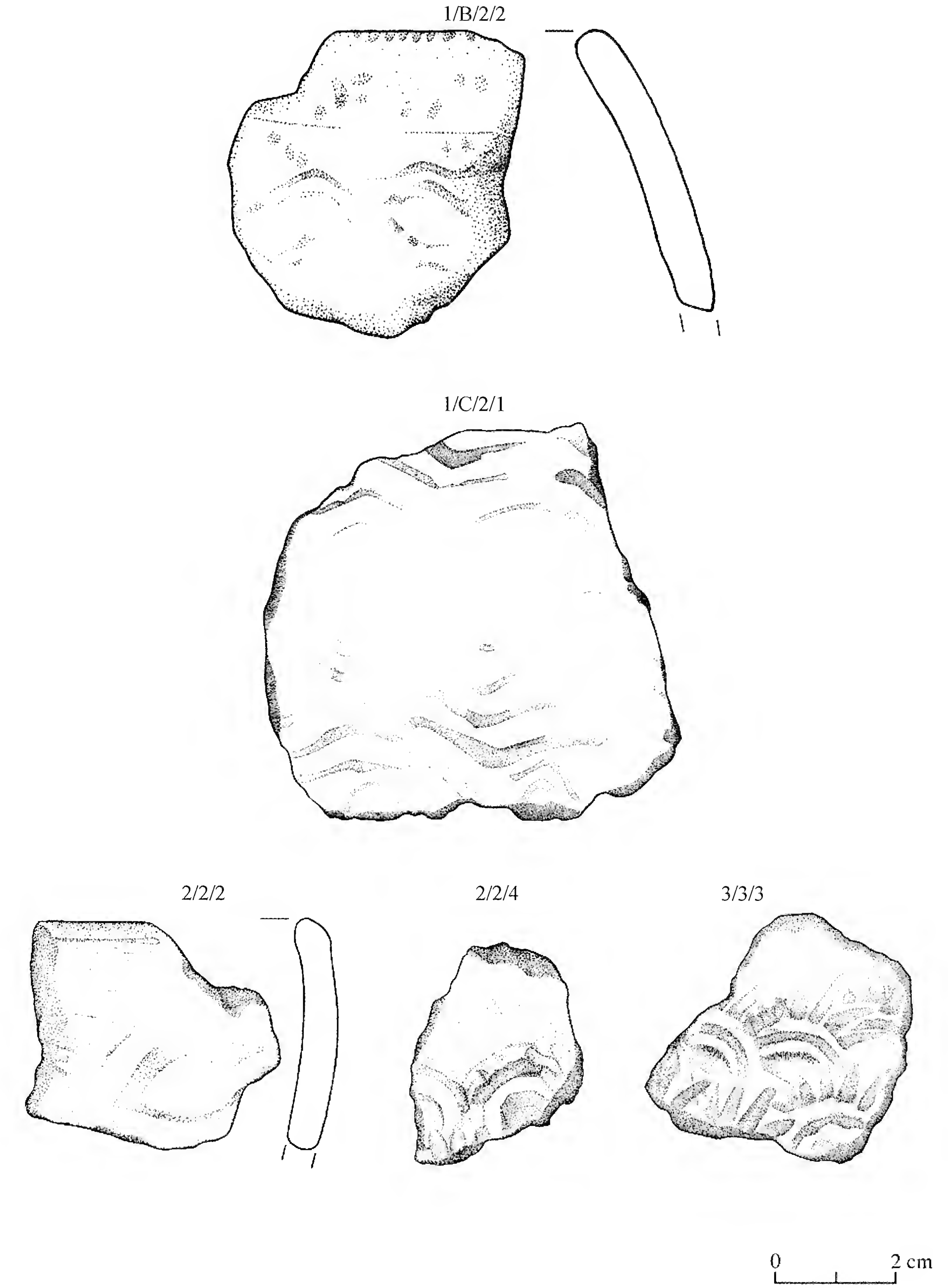
1/B/2/2



1/B/2/2

Appendix 7.1: *Continued.*

Broad-tooth scored and impressed "face"

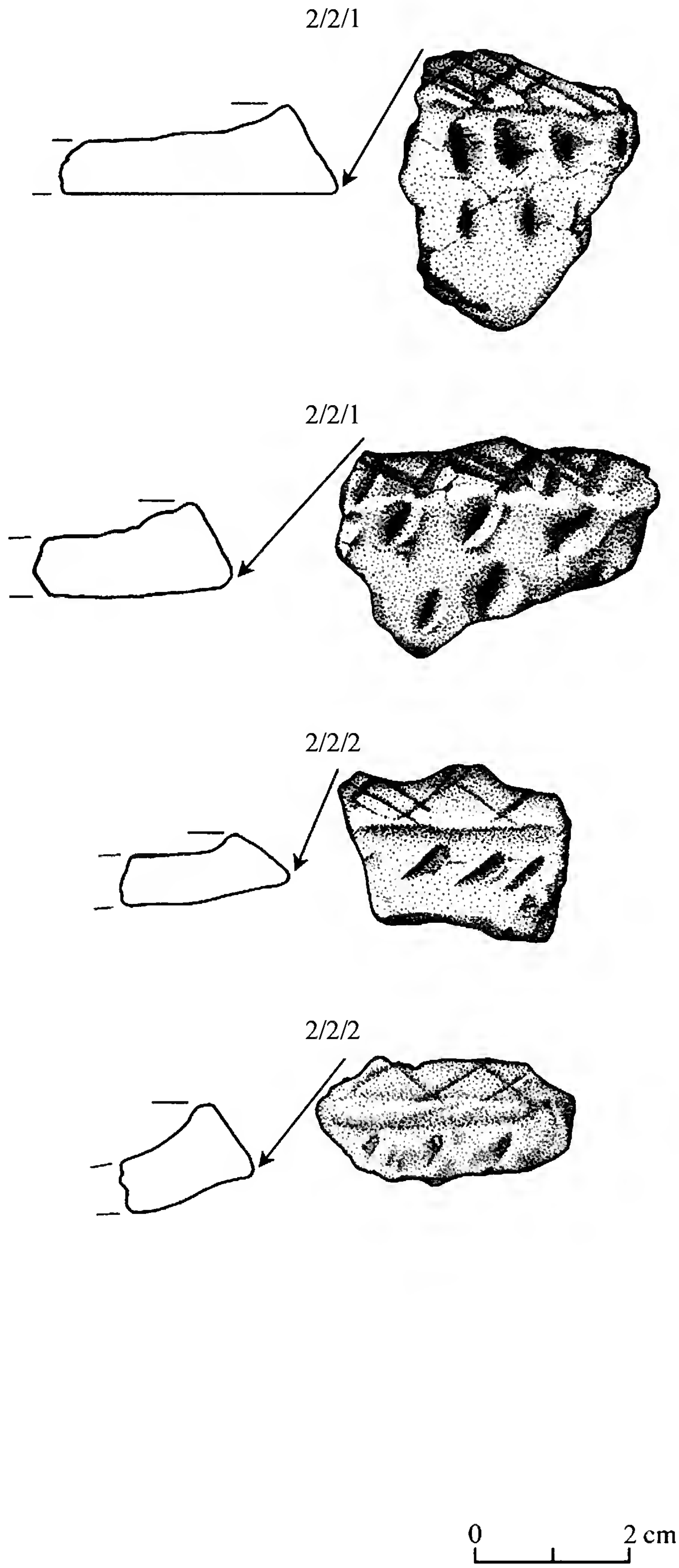


Appendix 7.1: *Continued.*

M-23

zoned punctate "eyes" below crosshatch incised & triangular lip

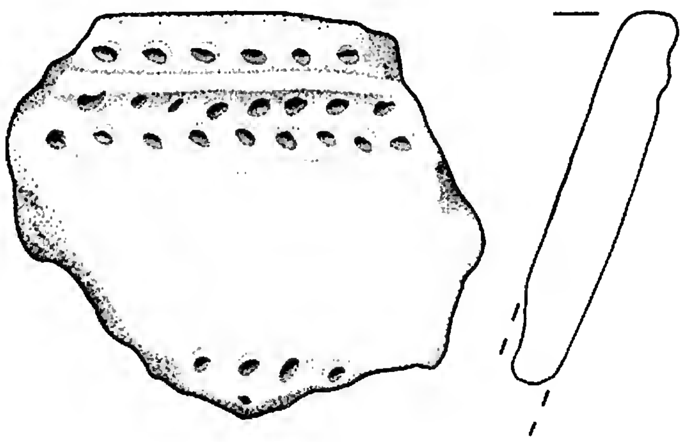
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	2	406	1
	1/A/2/3	1	171	1
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2		68	
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2	1	272	<1
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1		285	
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1	2	180	1
	2/2/2	2	59	3
Nyapin	2/2/3	2	119	2
	2/2/4	1	126	1
	2/2/5		34	
	2/3/1	3	77	4
Wain	3/1/1		29	
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	
	3/3/4		11	



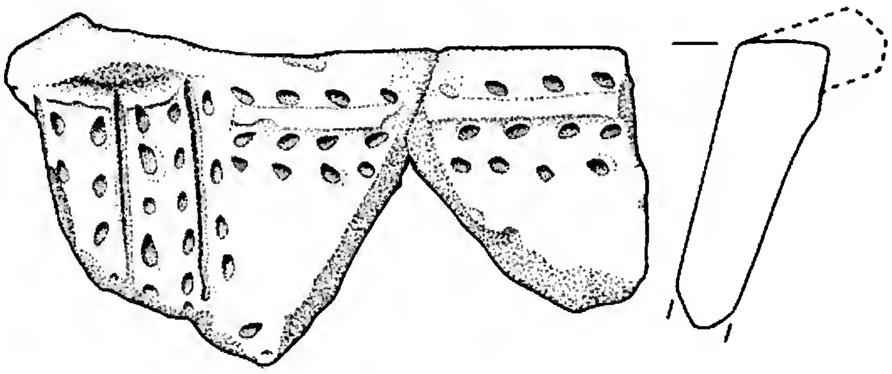
Appendix 7.1: *Continued.*

	M-24				zoned punctate "eyes" with appliqué band
	NGRP-46	*no.*	*total*	*%*	
surface	1/A-C/surface		53		
Wain	1/A/1/1		19		
	1/A/1/2		60		
Aiser	1/A/2/1		122		
	1/A/2/2	1	406	<1	
	1/A/2/3	1	171	1	
Sumalo	1/A/3/1		18		
	1/A/3/2		51		
	1/A/3/3		98		
	1/A/4/1		55		
	1/A/4/2		57		
Wain	1/B/1/1		32		
	1/B/1/2		68		
Aiser	1/B/2/1	6	300	2	
Aiser/Sumalo	1/B/2/2	1	272	<1	
Wain	1/C/1/1		32		
	1/C/1/2		62		
Aiser	1/C/2/1	2	285	1	
Wain	2/1/1		10		
	2/1/2		34		
Sumalo	2/2/1		180		
	2/2/2		59		
Nyapin	2/2/3		119		
	2/2/4		126		
	2/2/5		34		
	2/3/1		77		
Wain	3/1/1		29		
	3/1/2		16		
Aiser	3/2/1		23		
	3/2/2	3	20	15	
	3/2/3	1	72	1	
	3/2/4	1	90	1	
	3/2/5		27		
	3/3/1		36		
	3/3/2		51		
	3/3/3		34		
	3/3/4		11		

3/2/2



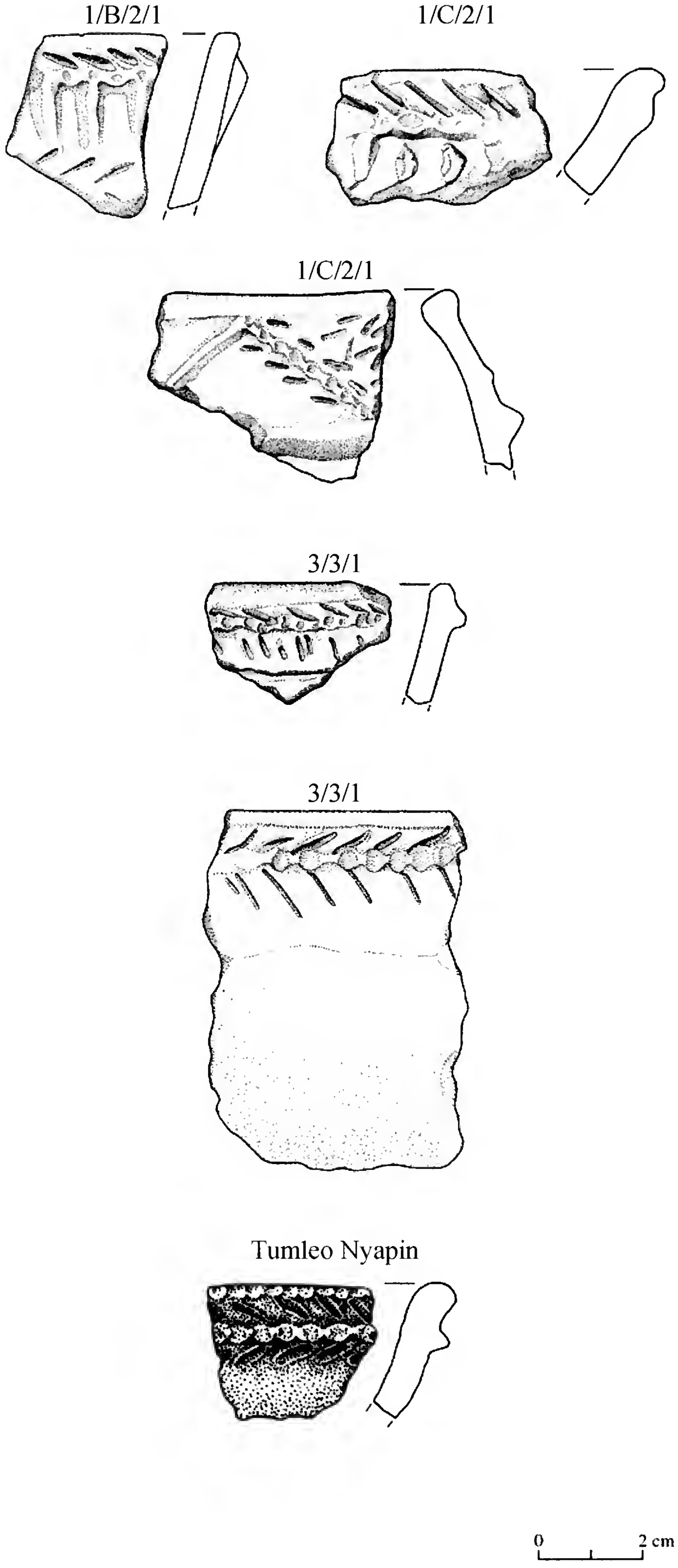
3/2/2



Appendix 7.1: *Continued.*

	M-25			
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1	5	122	4
	1/A/2/2	29	406	7
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2	2	68	3
Aiser	1/B/2/1	3	300	1
Aiser/Sumalo	1/B/2/2	13	272	5
Wain	1/C/1/1		32	
	1/C/1/2	1	62	2
Aiser	1/C/2/1	10	285	4
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
	3/1/2	2	16	13
Aiser	3/2/1	2	23	9
	3/2/2	1	20	5
	3/2/3	3	72	4
	3/2/4		90	
	3/2/5		27	
	3/3/1	2	36	6
	3/3/2	1	51	2
	3/3/3		34	
	3/3/4		11	

zoned diagonal punctate "eyes" with punctate appliqué band

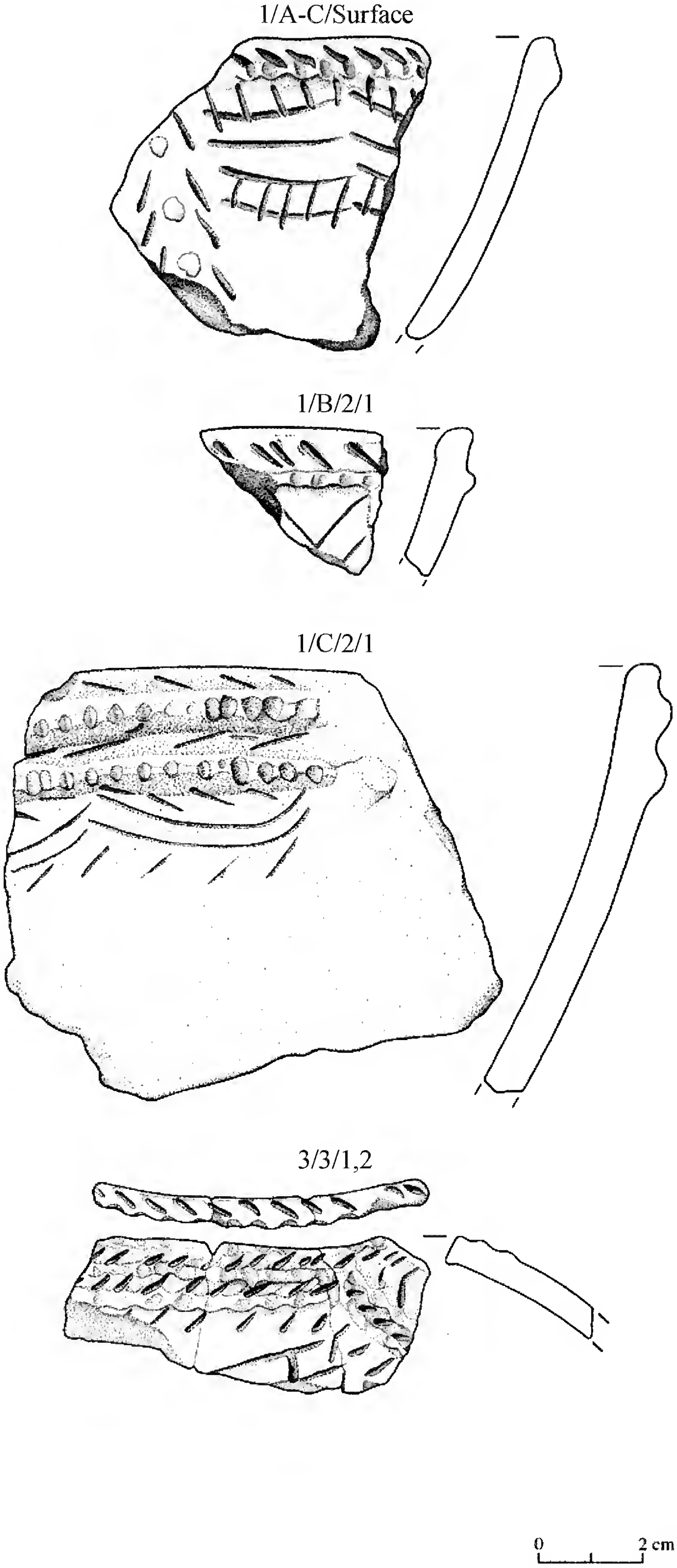


Appendix 7.1: *Continued.*

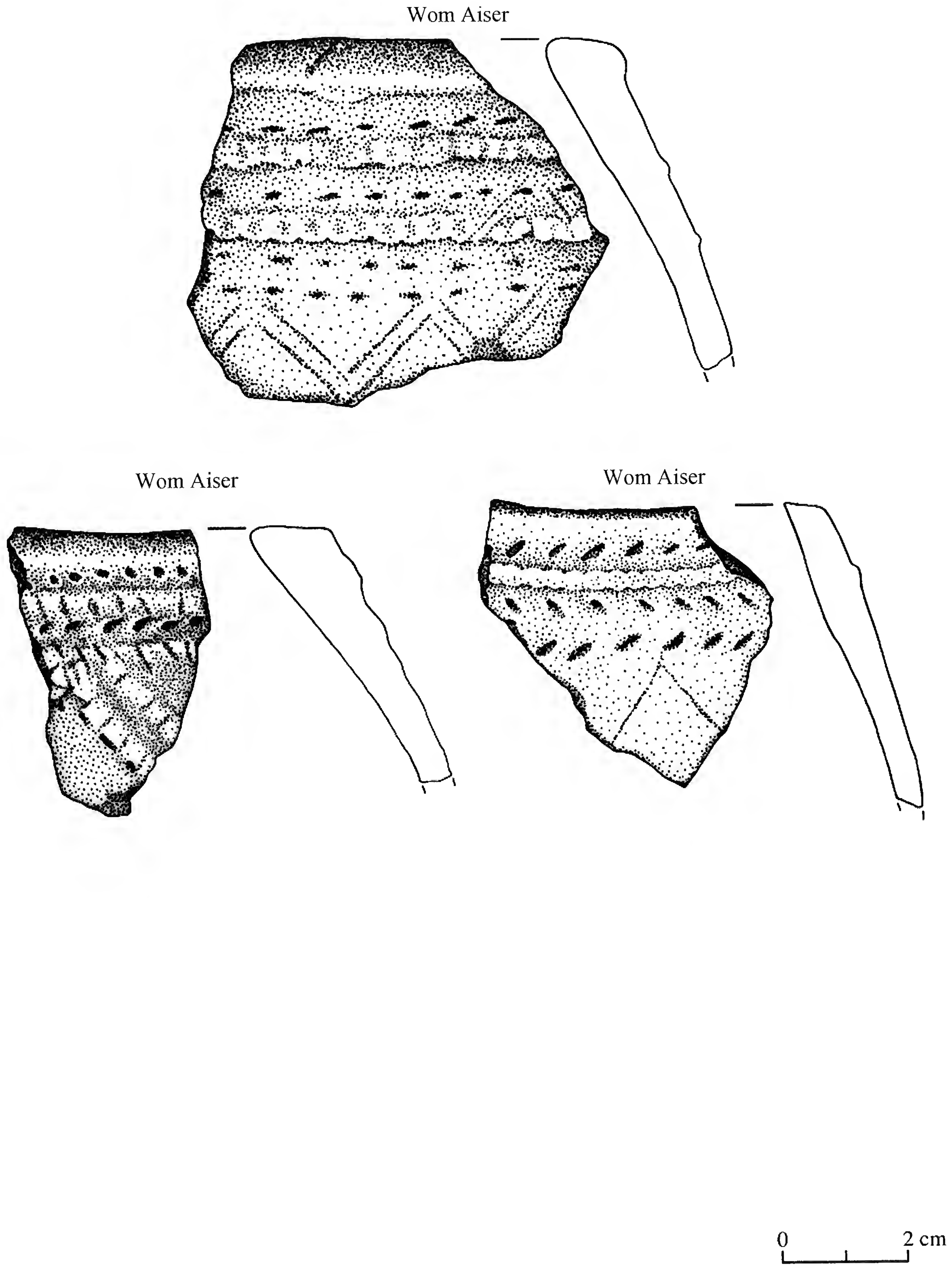
M-26

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface	1	53	1
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1		122	
	1/A/2/2	5	406	1
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	1	32	3
	1/B/1/2		68	
Aiser	1/B/2/1	3	300	1
Aiser/Sumalo	1/B/2/2	5	272	2
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1	6	285	2
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	1	29	4
	3/1/2		16	
Aiser	3/2/1	3	23	13
	3/2/2		20	
	3/2/3		72	
	3/2/4	4	90	4
	3/2/5	1	27	4
	3/3/1	6	36	17
	3/3/2	1	51	2
	3/3/3	1	34	3
	3/3/4	1	11	9

elaborated zoned diagonal punctate "eyes" with punctate appliqué band



elaborated zoned diagonal punctate "eyes" with punctate appliqué band

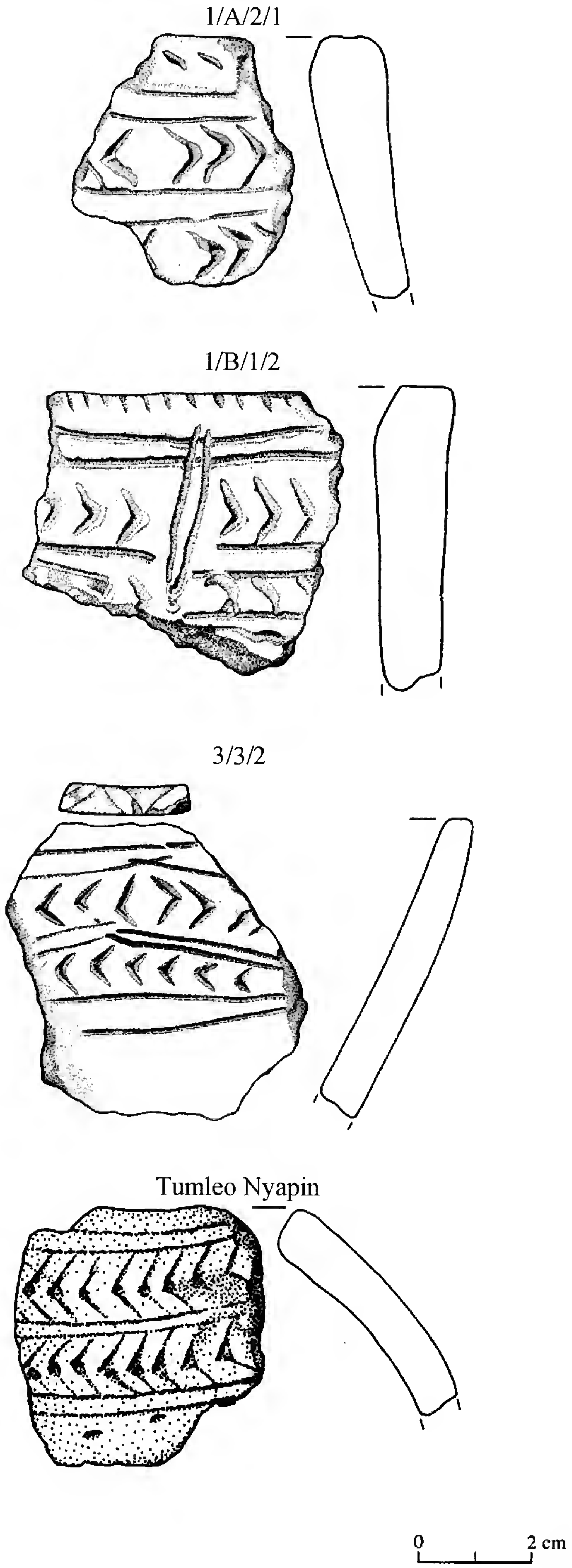


Appendix 7.1: *Continued.*

M-31

	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1	1	122	1
	1/A/2/2		406	
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1	1	32	3
	1/B/1/2	4	68	6
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2		272	
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1		285	
Wain	2/1/1		10	
	2/1/2		34	
Sumalo	2/2/1		180	
	2/2/2		59	
Nyapin	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1	1	29	4
	3/1/2		16	
Aiser	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2	1	51	2
	3/3/3	1	34	3
	3/3/4		11	

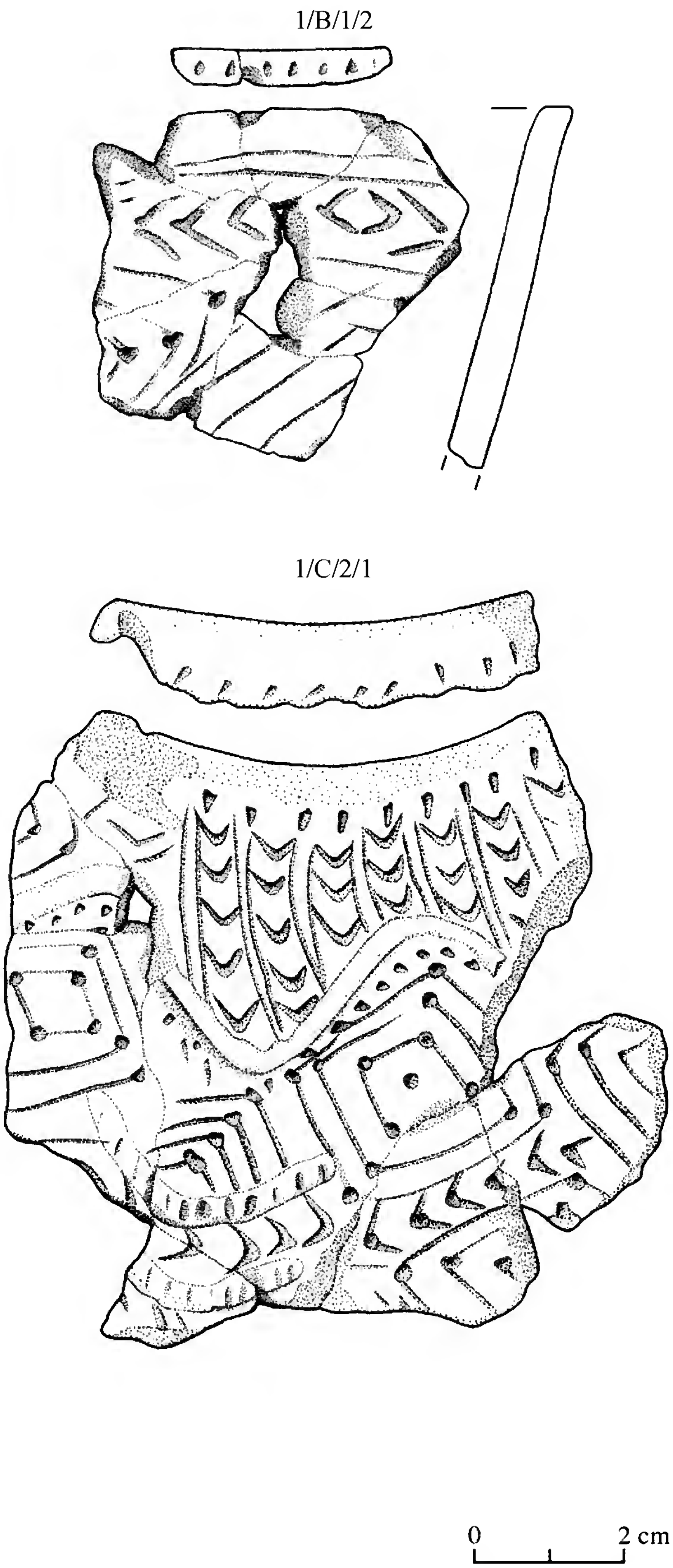
zoned herringbone designs below flat lip



Appendix 7.1: *Continued.*

	M-32			
	NGRP-46	*no.*	*total*	*%*
surface	1/A-C/surface		53	
Wain	1/A/1/1		19	
	1/A/1/2		60	
Aiser	1/A/2/1	1	122	1
	1/A/2/2		406	
	1/A/2/3		171	
Sumalo	1/A/3/1		18	
	1/A/3/2		51	
	1/A/3/3		98	
	1/A/4/1		55	
	1/A/4/2		57	
Wain	1/B/1/1		32	
	1/B/1/2	1	68	1
Aiser	1/B/2/1		300	
Aiser/Sumalo	1/B/2/2		272	
Wain	1/C/1/1		32	
	1/C/1/2		62	
Aiser	1/C/2/1	1	285	<1
Wain	2/1/1		10	
Sumalo	2/1/2		34	
	2/2/1		180	
Nyapin	2/2/2		59	
	2/2/3		119	
	2/2/4		126	
	2/2/5		34	
	2/3/1		77	
Wain	3/1/1		29	
Aiser	3/1/2		16	
	3/2/1		23	
	3/2/2		20	
	3/2/3		72	
	3/2/4		90	
	3/2/5		27	
	3/3/1		36	
	3/3/2		51	
	3/3/3		34	

zoned herringbone and "bulls-eye" designs below flat lip



Chapter 8: Historic and Modern Pottery in the Aitape Area

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Abstract

The shapes of prehistoric pottery vessels excavated in 1996 on Tumleo Island and at Aitape are described and compared with historic and modern pots from this area of New Guinea held in the ethnological collections of the Field Museum of Natural History. Four basic shapes are described. Two of these, *platters* and *bowls with carinations*, are not seen in the historic and contemporary ceramic collections. Additionally, a new shape is seen among historic but not contemporary vessels. Some decorative attributes used on prehistoric Wain Ware vessels occur also on Tumleo pots collected before World War I, but the decorations seen on most modern vessels are highly variable and cannot be readily interpreted as modern variations on older decorative themes. Uses are assigned to the various vessel shapes, and techniques of pottery making in historic and modern times are described on the basis of observations made by various investigators working in the area from 1902 through 1998. It is concluded that the same uses for pottery vessels as well as similar pottery-making techniques probably existed in prehistoric times, as in historic and in modern times.

Introduction

Before presenting my findings on historic and modern pottery in the Aitape area, I would like to review briefly what has previously been said in this monograph about prehistoric pottery found in this part of New Guinea. The excavations in 1996 on Tumleo Island and at Aitape (Chapter 6) yielded a large number of pottery sherds representing at least 492 vessels, most of which had been made locally at differing times over the last 2,000 years, as determined by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS; Chapter 13) and radiocarbon dating (Chapter 14). As part of our laboratory work with these ceramic finds, vessel shapes were partially reconstructed to the extent that the fragmentary condition of the sherds permitted, and decorative attributes and design motifs were classified and recorded (Chapter 7). On the basis of this composite evidence, we have concluded that there has been a single pottery-making tradition active in the Aitape area since the first appearance of this craft on Tumleo ~2,000 or more years ago (Chapters 7 and 14). On current evidence, however, we are uncertain how continuous this tradition has been on Tumleo Island itself (but see Chapter 13). More evidence is needed to determine whether the apparent chronological discontinuity we found there between what we have called the Nyapin and Sumalo wares is real or is due simply to the vagaries of archaeological sampling.

In this chapter, I describe the prehistoric vessel shapes we have identified thus far, and then compare these with the shapes and also with the decorative elements characteristic of historic and modern Tumleo pottery. Using information from historic and modern sources, I then consider what may have been the uses of these differently shaped prehistoric vessels as well as what methods may have been used in their manufacture. I will answer the following specific questions:

1. Do the shapes reconstructed for prehistoric vessels resemble the shapes of historic and modern pottery manufactured in the Aitape area, and what are the recorded uses of the historic and modern vessels?
2. What evidence is there for stylistic continuity among the designs/decorations on prehistoric, historic, and modern Tumleo vessels (the main center of pottery production still active in the Aitape area)?
3. Given what is known about historic and modern pottery production on Tumleo, what inferences may be drawn about the production techniques used locally in prehistoric times?

Evidence for Continuity in Vessel Shape

As just noted, we have reconstructed at least some of the shapes of vessels popular at Aitape in prehistoric times using pottery sherds excavated on Tumleo and elsewhere representing the four pottery wares described in Chapter 7. To learn whether these shapes were also being made in this region in historic times—and may possibly still be in production—we examined historic and contemporary pots in the ethnographic collections at the Field Museum of Natural History from Tumleo and elsewhere along the Sepik coast, and then compared these pots with our reconstructions of prehistoric vessels.

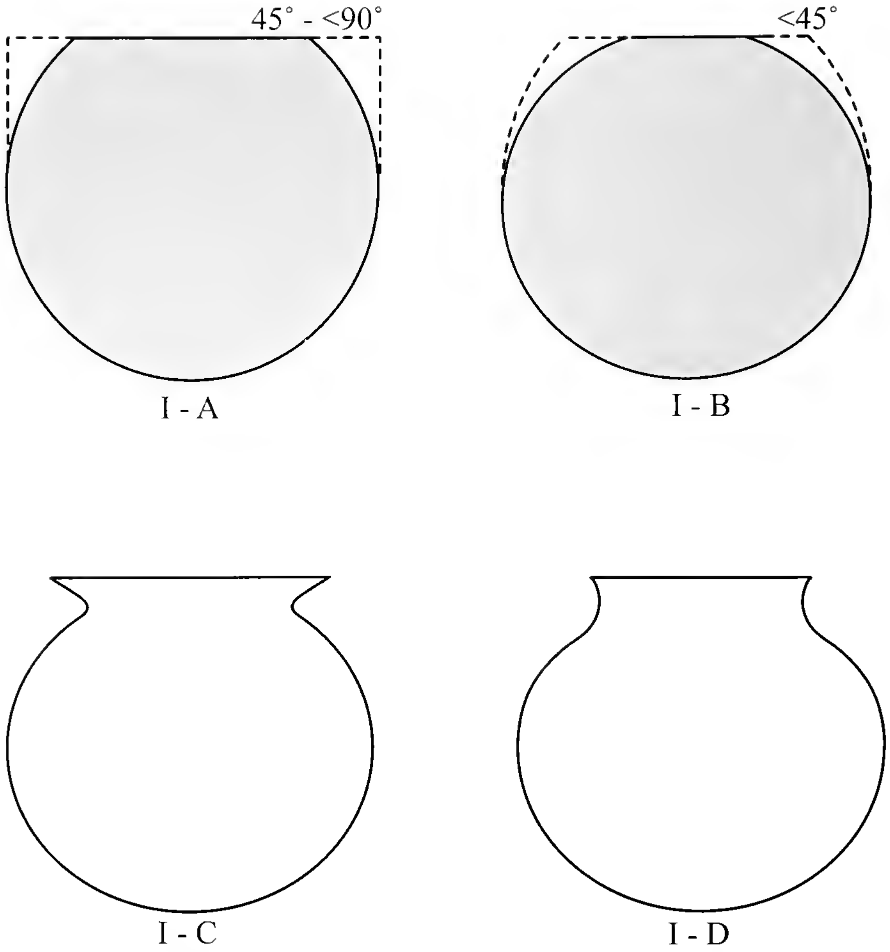


FIG. 8.1. Idealized prehistoric, historic, and modern ceramic vessel shapes (**I-A–I-D**).

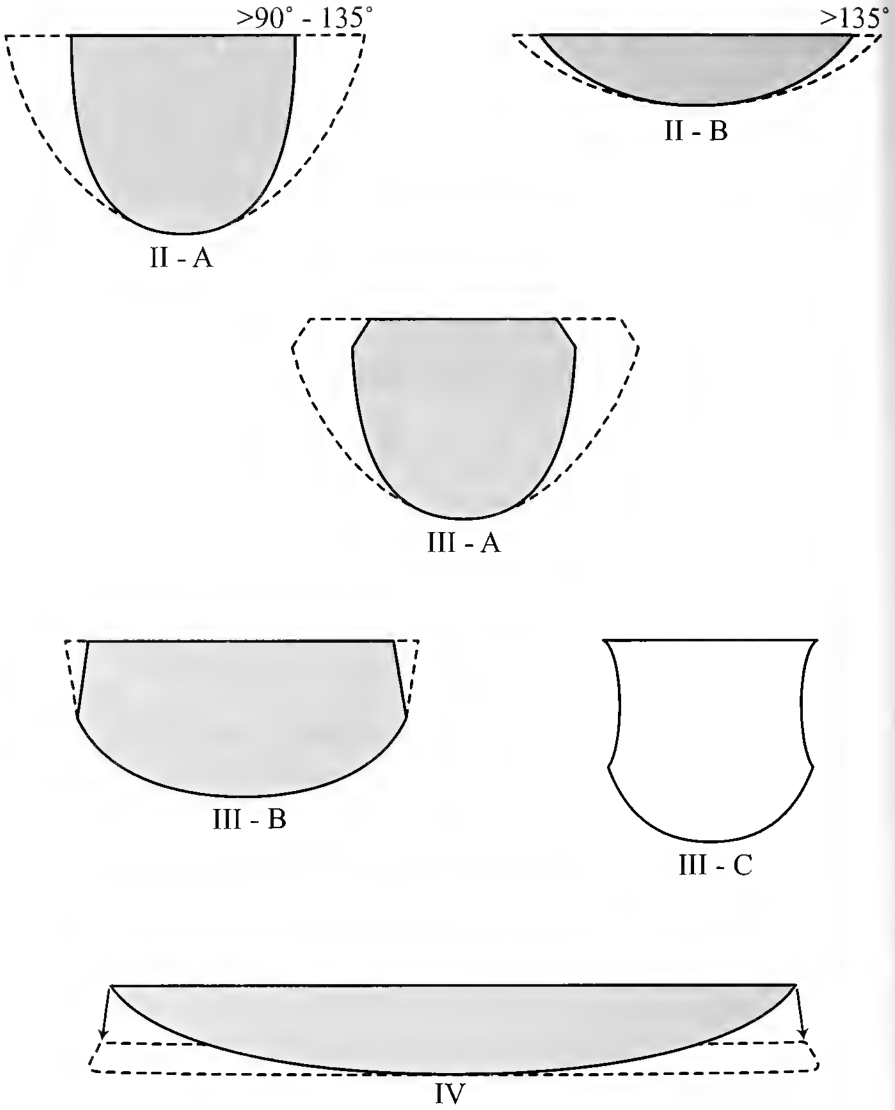


FIG. 8.2. Idealized prehistoric, historic, and modern ceramic vessel shapes (**II-A–IV**).

Prehistoric Pottery

Prehistoric pottery in the Aitape area had at least four primary forms, as shown in the basic vessel types depicted in Figures 8.1 and 8.2. Idealized reconstructions are seen in Figures 8.3–8.5. Except for platters (IV), all these forms were evidently round-bottomed, as shown in these reconstructions:

1. Round bowls with either inverted (forms I-A and I-B) or everted rims (I-C and I-D)
2. Bowls with open rims (II-A and II-B)
3. Bowls with carinated rims (III-A), or shoulders (III-B), and deep carinations (III-C)
4. Flat or quite shallow platters (IV)

Table 8.1 shows the distribution of the several hundred examples we were able to reconstruct across the four prehistoric wares described in Chapter 7 as well as the historic and modern pots in the collections at the Field Museum. This table should be read with two caveats in mind. First, everted rim pots (I-C and I-D) are much more common than suggested by these figures. Both of these two closely similar forms are often readily identifiable in assemblages, unlike the other forms. The actual values reported for I-C and I-D in Table 8.1 are the number of sherds seen with fairly complete rim and body profiles (i.e., sherds with intact lip edges as well as everted rim and upper body profiles). Second, the values reported in all instances are *observed* frequency counts only; these values should not be used for statistical comparison between the wares represented. Additionally, the seven items listed in Table 8.1 under the platter category (IV) for Aiser Ware came from excavation units chronologically assignable to this ware category. However, most if not all of the particular sherds appear to be from Nyapin or Sumalo vessels (except possibly Appendix 7.1, B-11, 2/2/1). Their presence in these excavation units may be due to stratigraphic mixing. On present evidence, therefore, we judge that there is no certain evidence that ceramic platters were still being produced locally when Aiser or Wain wares were in fashion in the Aitape area.

Historic and Modern Pottery—We studied the Museum's collections of historic and modern pottery from Tumleo Island (Table 8.2) to answer a basic question: Do the shapes

TABLE 8.1. Distribution of shapes seen in prehistoric, historic and modern pottery (for shapes, see Figs 8.1 and 8.2).

Category	I-A	I-B	I-C	I-D	II-A	II-B	III-A	III-B	III-C	IV
Modern	10	0	0	5	1	1	0	0	0	0
Historic	12	9	11	10	3	9	0	0	11	0
Wain	17	9	1	1	20	9	1	3	0	1
Aiser	33	6	14	17	110	33	2	2	0	7
Aiser/Sumalo	2	2	1	3	30	11	0	0	0	4
Sumalo	1	0	0	1	15	9	1	2	0	6
Nyapin	2	0	0	0	13	2	0	5	0	14

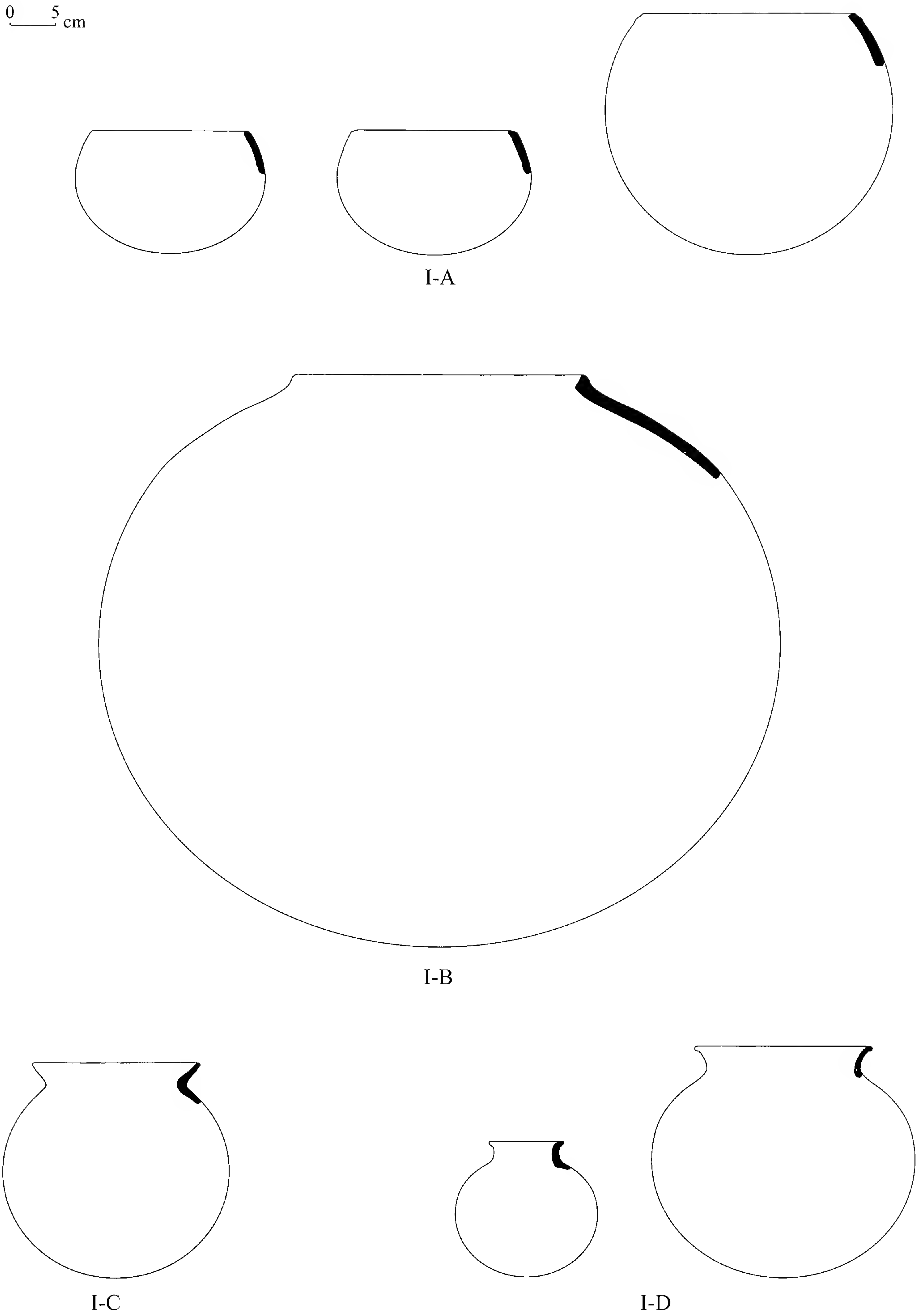
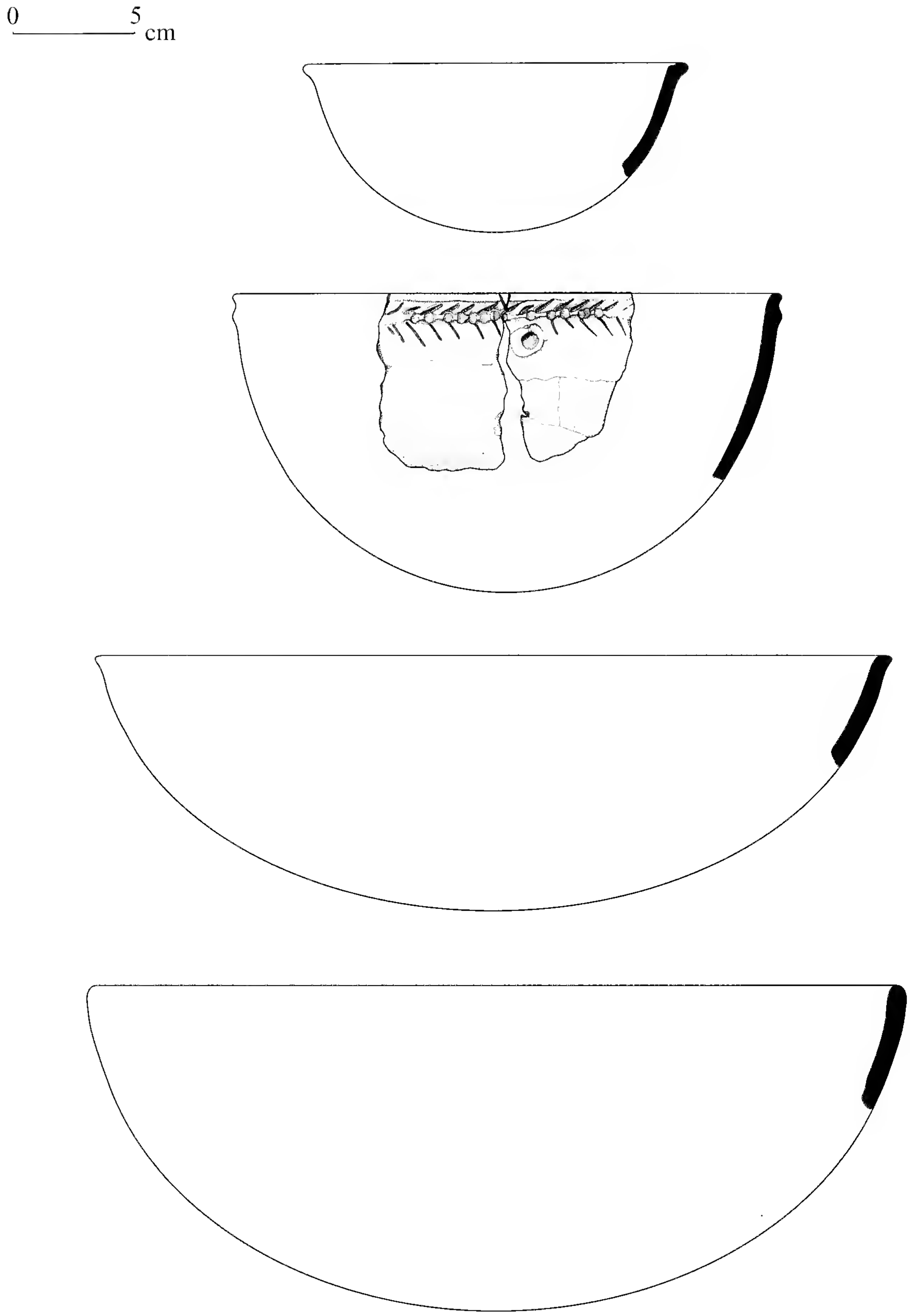
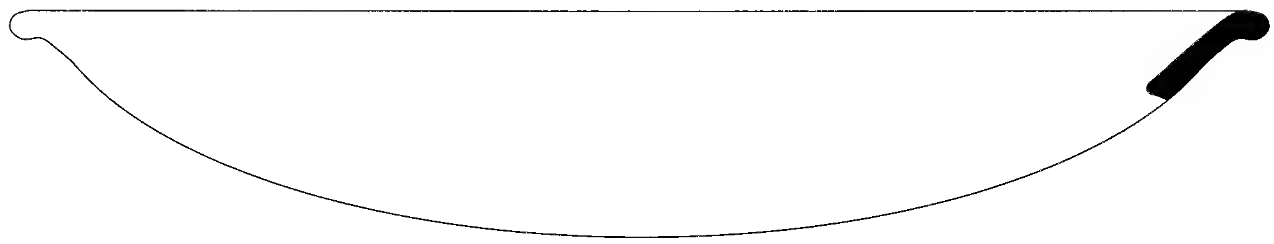


FIG. 8.3. Reconstructed shapes of prehistoric bowls from NGRP 46: **(I-A)** 1B/2/2, 2/2/3, 3/2/1; **(I-B)** 1C/2/1; **(I-C)** 3/2/2; **(I-D)** 1C/2/1, 1A/3/3.



II-A



II-B

FIG. 8.4. Reconstructed shapes of prehistoric bowls from NGRP 46: (**II-A**) 2/2/4, 3/3/1, 2/2/3, 1B/2/2; (**II-B**) 2/3/1.

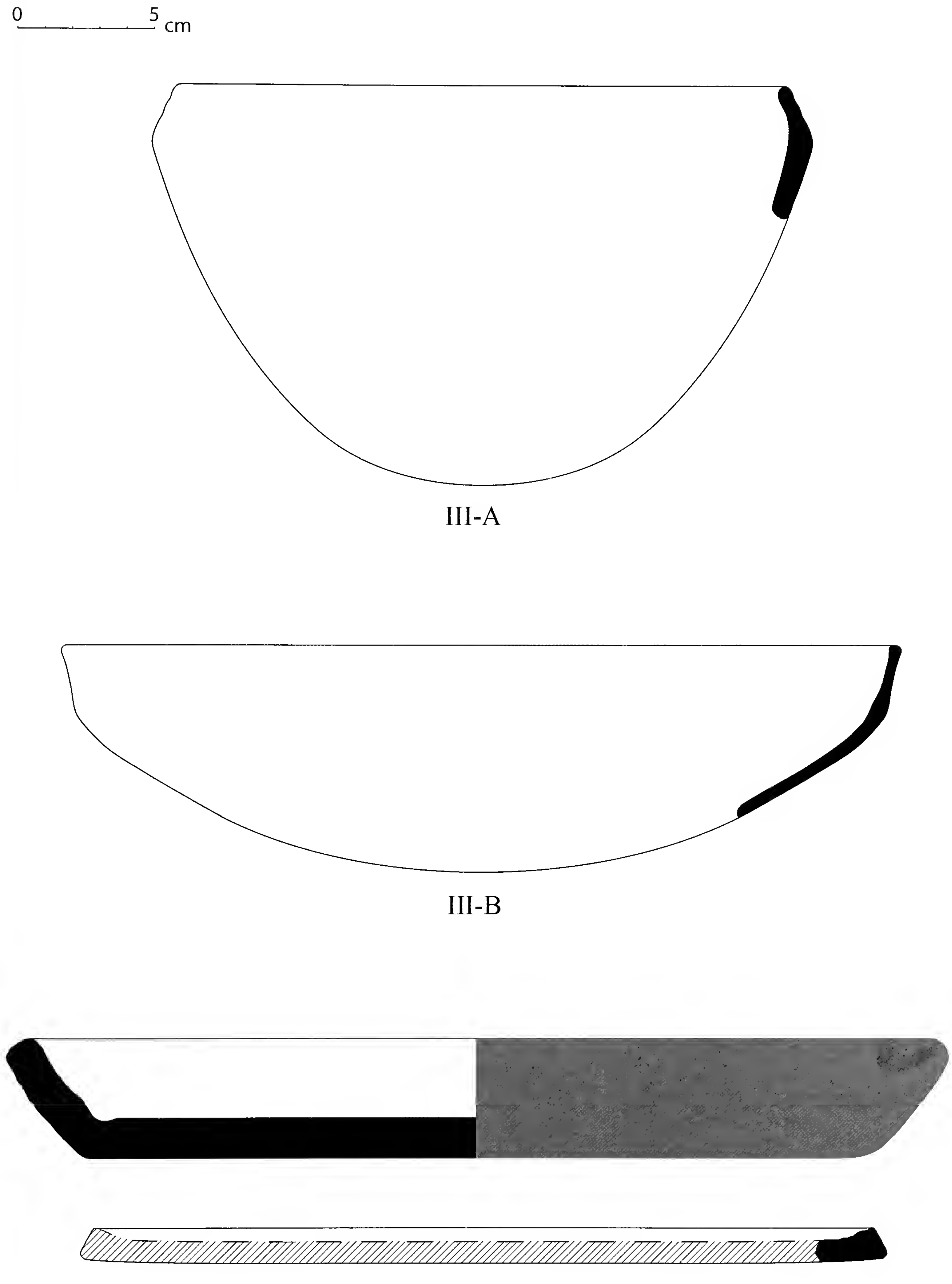


FIG. 8.5. Reconstructed shapes of prehistoric bowls and platters: (**III-A**) NGRP 17 surface; (**III-B**) NGRP 23 2A/C/1; (**IV**) NGRP 46 1A/3/1, NGRP 46 2/2/1.

reconstructed for prehistoric vessels resemble the shapes of historic and modern pottery made in this area? Although 96 vessels obtained from Tumleo Island are available at the Museum for study, 11 of them have been excluded from the analysis reported here. Two are documented in the Museum's archival records as coming originally from elsewhere in northern New Guinea—from Dallmann Harbor (modern Wewak east of Aitape), and from somewhere inland at the coastal village of Yakamul. The remaining nine pots are so different in their shape or decorative appearance from pots known to have been made on Tumleo before World War I that their manufacture elsewhere seems probable (Fig. 8.11a–h, j; Fig. 8.11i has been included in this figure as an example of a pot made on Tumleo before World War I). The observations reported here, therefore, are based on 85 whole pots in the Museum's collections, all of which are known to have been made on Tumleo Island during the 20th century or, in some instances, perhaps during the latter 19th century.

Similarities and Differences

The historic vessels (i.e., pottery collected on Tumleo before World War I) in the Museum's collections are predominantly round pots with inverted or everted rims and bowls with open rims (categories I and II). Bowls with carinated rims or shoulders (III-A and III-B) and platters (IV) are not present, but a new shape occurs—bowls with deep carinated shoulders (III-C). Of the modern vessels in the collections (i.e., those made on the island after World War II), 15 are round bowls with inverted or everted rims (I-A and I-D), and two are open bowls (II-A and II-B; Fig. 8.2). No platters or bowls with deep carinations are in evidence. Several bowls in category I in both historic and modern vessels have handles or holes around the rim. None of these attributes is found among the prehistoric vessels.

Therefore, in light of these admittedly limited observations, it appears that vessel forms popular in prehistoric times, notably those in category I, have remained in fashion right up to the present day (Chapter 15), some with modifications, namely, the addition of handles and holes that may have been added for useful or decorative purposes. Three forms, III-A, III-B, and IV, have so far been found only in the Nyapin and Sumalo wares. A third form, III-C, seen in our museum collections dating to before World War I, may not have been used in prehistoric times.

Vessel Use and Function

There is at present no direct archaeological evidence bearing on the prehistoric use or function of the differing pot shapes

TABLE 8.2. Collections of pottery vessels at the Field Museum of Natural History from Tumleo Island and elsewhere in the Aitape district.

Ethnographic collection	Date of collection	No. of vessels
A. B. Lewis	1909–1913	22
George A. Dorsey	1908	19
Captain H. Voogdt	1906–1908	38
Walgreen Expedition	1990	2
A. B. Lewis Project	1993–1994	15
Total		96

found in the Aitape area, but there is a body of published information documenting the conventional uses of historic and contemporary pots. This documentation was consulted to develop a list of the possible uses for the various reconstructed prehistoric vessel shapes (Table 8.3):

1. Mathius J. Erdweg, one of the first Christian missionaries to settle on Tumleo Island, published in some detail his own firsthand observations about life on Tumleo, including pottery making (Erdweg, 1902).
2. Albert Lewis, the anthropologist and museum curator who traveled extensively throughout Melanesia on behalf of the Museum before World War I, visited Tumleo Island in September 1909. In his diaries (Welsch, 1998), Lewis drew the shapes of pottery vessels being made then on Tumleo, and also noted what vessels of these shapes were used for.
3. In more recent times, Patricia May and Margaret Tuckson (1982) have described the different kinds of vessels still being made on Tumleo in the 1970s as well as local type designations and uses. Like Erdweg and Lewis, May and Tuckson also had the good fortune to see pottery making being done on Tumleo firsthand during their fieldwork in the 1970s in Papua New Guinea. Elsewhere in New Guinea, they were not always as fortunate, although they were often at least able to interview potters in many New Guinean communities and see useful demonstrations of their practices and procedures.
4. Finally, as part of field investigations done by the Museum in 1993–1994 and later (Anthropology Department Records), Robert Welsch documented the modern uses of pottery on Tumleo and elsewhere along the Sepik coast in the 1990s.

As summarized in Table 8.3, the historic and modern pottery in the Museum's collections can be assigned to five basic functional types, or categories:

1. Cooking pots (*takum*, or *perlpir*)—small, round-bottomed spherical or ellipsoid pots, with or without an everted rim (Fig. 8.6).
2. Ornamental/storage vessels (*pier atjek vol*)—small round, spherical, or ellipsoid pots with one to four handles over the opening or two to six holes around and below the rim (Fig. 8.7).
3. Sago stirring or storage pots (*sal*, *sujanu*, or *lup malangon*)—large, generally thick-walled, round-bottomed, spherical, or straight-sided vessels often considerably bigger than vessels used for cooking (Fig. 8.8).
4. Sago frying pans (*tapel*) and lids (*tapel tjup*) for cooking pots or sago storage jars—a deep or shallow bowl form (Fig. 8.9).
5. Ritual baby washing pots (*su lapij puak*)—round-bottomed pots with slightly concave sides (Fig. 8.10). May and Tuckson (1982, p. 310) say this type of pot is also used "to leave prepared food in the house for old people who have been left on their own for the day." However, Lewis (Welsch, 1998, p. 86) reported that such pots are hung bottom side up outside an *alol* (men's house), and may also be used "for sago or cooking."

Two pots in our sample of 84 Tumleo pots in the Museum's collections—both made before World War I and each without documentation on its use, or function—do not seem to fit into any of these five basic vessel types. Both are large, thick-

Table 8.3. Descriptions and functions for historic and modern pottery.

Functional category	Erdweg (1902)	Lewis, 1909	May and Tuckson (1982)	Welsch, 1990s
Sago stirring	*sal*—semispherical pot for sago porridge	*sal*—same as Erdweg	*sal*—round-bottomed, spherical or straight-sided	*sal*—similar to Fig. 8.8h *sal ahin*—see Fig 8.8g
Sago storage	*sujanú*—large almost spherical pot with neck; holds about 30 liters *lup malangón*—round pot smaller than *sujanú* but without neck	*sujanú*—same as Erdweg *lup malangón*—same as Erdweg	*suyann*—very large round pot, about 60 cm high *lup mlangon*—round-based spherical pot without neck	
Sago frying	*tapél*—flat, platter-shaped pot		*tapel*—round-based semiellipsoid bowl	
Cooking	*per*—round pot with everted rim; holds 8–15 liters or more for cooking water, potato, meat, vegetables *takum*—small half-spherical pot	*per*—same as Erdweg *per aterapin*—small, round pot[a] for cooking fish and so on *takúm*—same as Erdweg; for sago	*pier* or *pier ahin*—spherical and round-based pot with short neck and everted rim *takum*—pot for meat and vegetables and boiling water for sago; smaller than *pier*; may be ellipsoid or spherical	*pir*—for fish or vegetables; see Fig. 8.6b, e *pir ahin*—round pot with everted rim[b] for greens or vegetables; similar to Fig. 8.8g *pir tagulin*—for fish or vegetables; see Fig. 8.6f *takum*—small pot for greens or vegetables; see Fig. 8.6d, h, i[c]
Vessel lid	*tapel tjup*—flat platter used as cover for the *sujanú* (same as *tapél*)		*tapel tjup* or *karap tjup*—same shape as *tapel*; some have scalloped edges; scallops are for venting steam (Parkinson, 1979, p. 82)	*karap tyup*—see Fig. 8.9f
Baby washing, sago, or cooking			*sulapij puak*—round-bottomed with slightly concave or convex sides; used to hold water for the traditional washing of the newborn or to leave food in the house for old people who are home alone	*sulabipuwak*—cooking pot; see Fig. 8.7f
Ornamental/storage vessel	*su lapj púak*—bell-shaped with opening on top; for decoration or cooking if no other pots available *per atjék vol*—spherical with two to four small holes ~5 cm in diameter in a circle at the upper middle of the pot; only for decoration	*su lapij puak*—same as Erdweg; "hung, bottom side up, on outside '*alol*' used also for sago or cooking" *pier atjek vol*—same as Erdweg	*pier atjek vol*—spherical food storage pot, hung from rafters; three or four handles above the top opening or two to six holes around the top rim	*pir acok wol*—formerly used to decorate men's houses; now decorative, may also be hung up and used to hold things; three openings; similar to Fig. 8.7f
Potter's work bowl			*karap*—same shape as *tapel*; to hold pot during manufacture; roughly finished and never decorated or blackened on the outside; made in a range of sizes	

[a] Described as illustrated.
[b] Described as seen in Field Museum collection.
[c] Figure 8.6i is an innovative style.

walled, boat-shaped pots: a vessel shape that is unique (Fig. 8.11j) and is not at all characteristic of pots made on Tumleo Island.

After observing the shapes found in prehistoric pottery vessels as shown in Figures 8.1–8.5 in relation to the functional categories outlined in Table 8.3, I believe that until there is evidence to the contrary, it seems reasonable to assume that the known functions of these shapes today were probably much the same in earlier times.

Evidence for Continuity in Vessel Design and Decoration

In Chapter 7, we described the kinds of decorative treatment given ceramic vessels made in the Aitape area in prehistoric times. In light of the fact that pots similar in shape and perhaps also in function are still being made on Tumleo, is there evidence also for ceramic design continuity on Tumleo between prehistoric and more recent times?

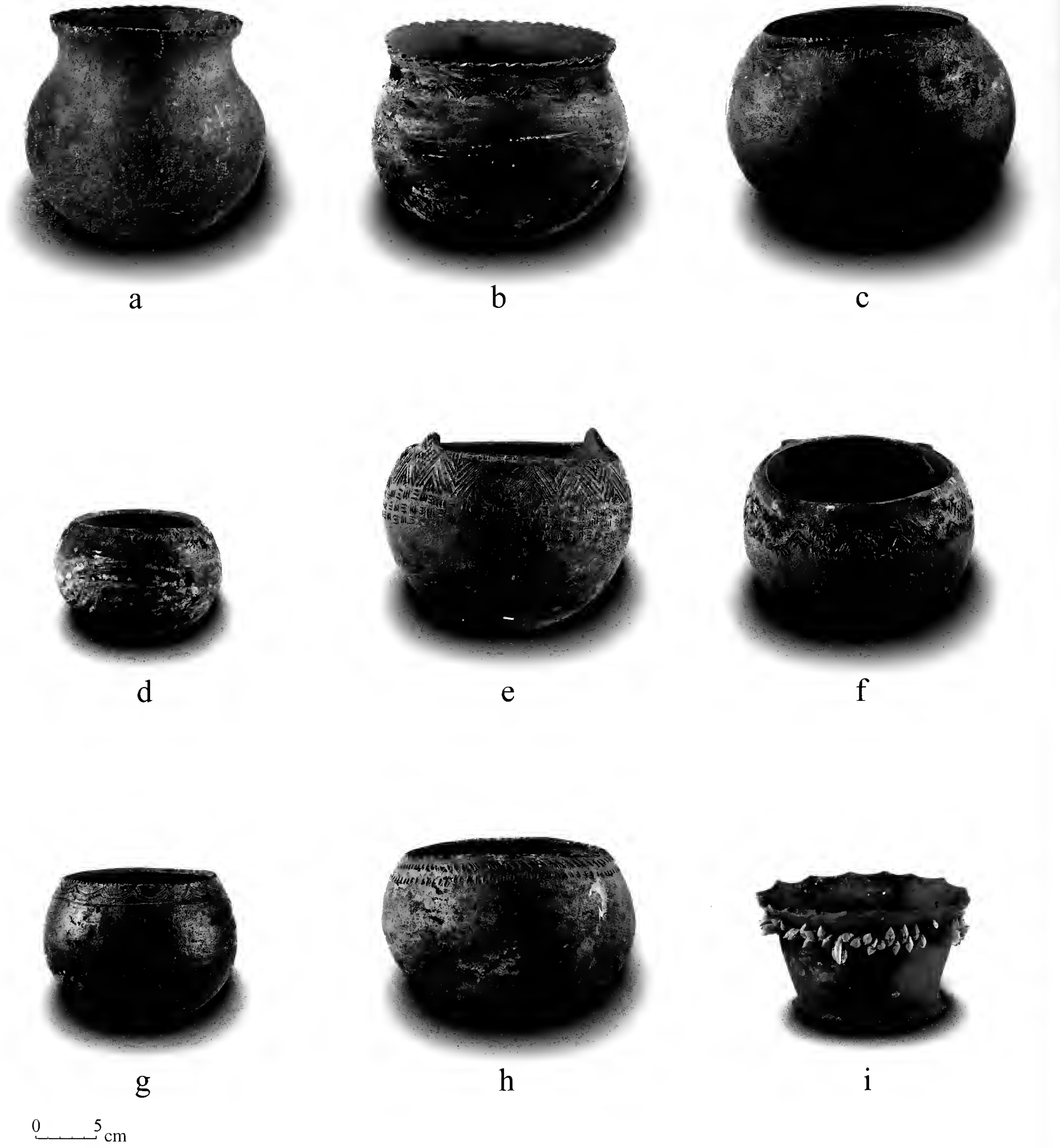


FIG. 8.6. Cooking pots from Tumleo Island, Sepik coast, Papua New Guinea, photographed by John Weinstein: (**a**) FMNH no. 137900, A. B. Lewis Collection, 1909–1913, FMNH neg. no. A114503_02d; (**b**) *pir*—basic cooking pot—made by Ropina Ewa from inland Sapi, no. 250041, A. B. Lewis Project Expedition, 1993–1994, A114534_01d; (**c**) no. 250095, Lewis Project Expedition, A114535_02d; (**d**) *takum*—small cooking pot for cooking greens—made by Ropina Ewa from Sapi Village, no. 250039, Lewis Project Expedition, A114516_01d; (**e**) *pir* pot—for cooking fish or vegetables—made by Ana Ramoi from Sapi Village, no. 250034, Lewis Project Expedition, A114513_02d; (**f**) *pir tangulin*—for cooking fish or vegetables—made by Ana Ramoi from Sapi Village in 1993, no. 250035, Lewis Project Expedition, A114514_01d; (**g**) *pir takum*—from Aopias Village—no. 250053, Lewis Project Expedition, A114520_01d; (**h**) *takum*—from Sapi Village, for cooking greens or vegetables—made in Ainamul Village by Salamain, no. 250043, Lewis Project Expedition, A114517_01d; (**i**) *takum*—from Sapi Village, decorated pot or bowl—made in Ainamul Village by Etmil, no. 250044, Lewis Project Expedition, A114518_01d.

We noted in Chapter 7 how one design motif evidenced in the prehistoric Aitape ceramic sequence—one we call the "eye" motif—apparently became more and more abstract over the course of time following the popularity of Nyapin Ware around 1,500–2,000 years ago. While a variant of this motif was still being carved around the exterior (i.e., reverse) rims of wooden platters made on the Sepik coast during the 20th century (Terrell & Schechter, 2007, figs. 8, 12, and 27; see Chapter 9), we have not found this motif in any recognizable form on any of the historic and modern pottery vessels in the collections at the Museum.

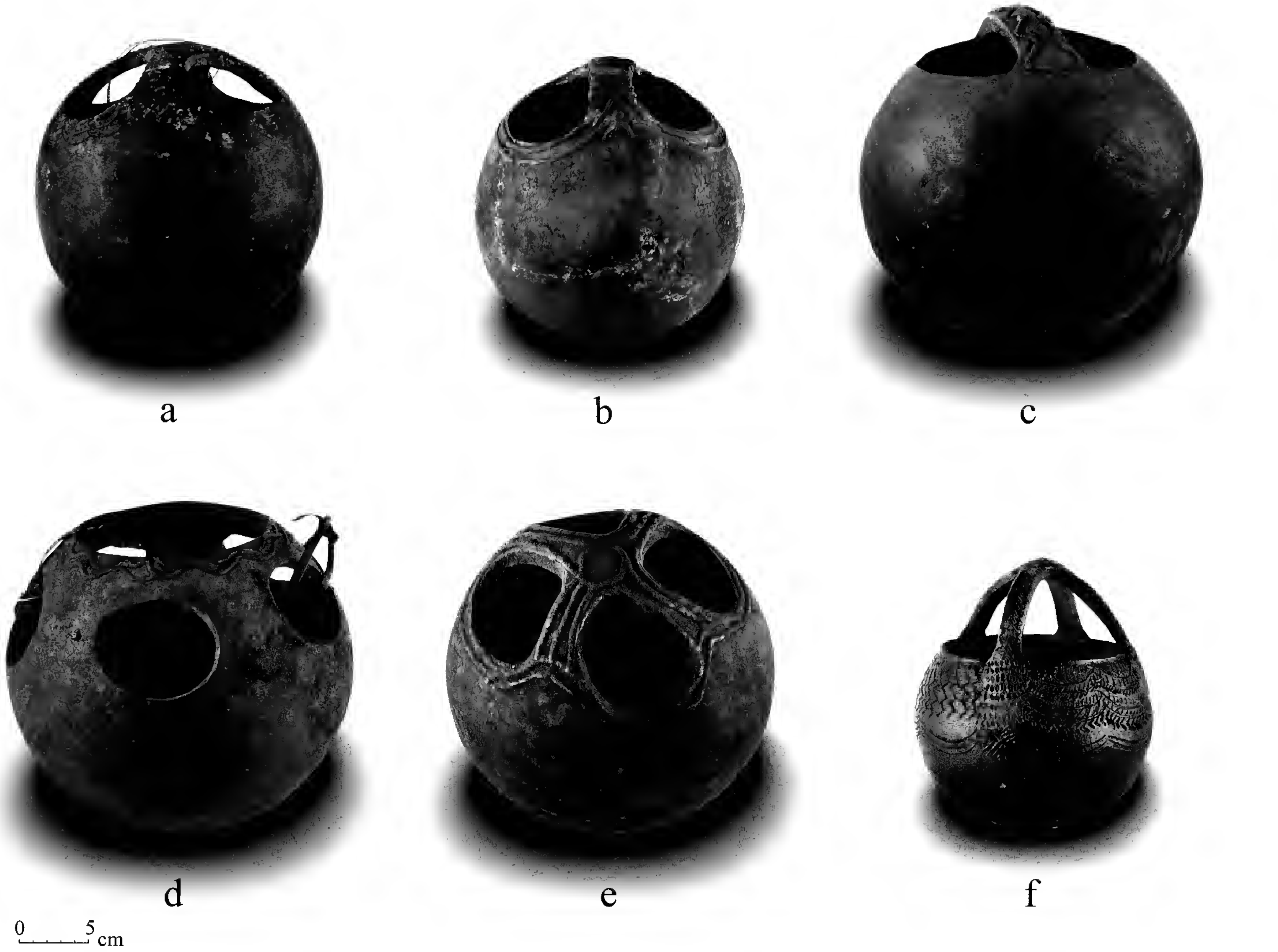


FIG. 8.7. Ornamental storage vessels from Tumleo Island, Sepik coast, Papua New Guinea, photographed by John Weinstein: (**a**) FMNH no. 137903, A. B. Lewis Collection, 1909–1913, FMNH neg. no. A114523_02d; (**b**) no. 147889, Capt. H. Voogdt Collection, 1906–1908, A114525_02d; (**c**) no. 147898, Voogdt Collection, A114526_01d; (**d**) no. 147980, George A. Dorsey Collection, 1908, A114512_01d; (**e**) no. 147900, Voogdt Collection, A114507_02d; (**f**) *sulabipuwak*—made by Ana Ramoi, decorations incised by daughter Helen Balam Naway—no. 250046, A. B. Lewis Project Expedition, 1993–1994, A114519_02d.

While certain basic design attributes—such as punctation and the use of straight or wavy appliqué bands and nubbins—occur on 20th-century Tumleo pots (Fig. 8.8a–f), it is a moot question how much should be made of parallels drawn between prehistoric and recent Tumleo pottery based on such generic design traits. More credible resemblances, however, can be found between incised Wain Ware attribute themes and the somewhat more open and expansive designs on Tumleo pots collected before World War 1 (Figs. 8.8a and 8.10a, c, d). On the other hand, the same is far less confidently said about the designs incised on pots collected in the 1990s, which are highly variable and seemingly idiosyncratic (e.g., Figs. 8.6b–i and 8.8g, h).

Why modern pottery made on Tumleo shows so little evident design continuity with the past is an open research question. The surface collections made on Tumleo at Ainamul hamlet and elsewhere (Chapter 5) show unmistakably their Wain Ware heritage (e.g., Fig. 5.13g), as do the large sago storage vessels from this island in the Museum's own ethnographic collections (e.g., Fig. 8.8). Evidently, the disruptions of World War II may have irreparably broken the cognitive, symbolic link previously so evident since the heyday of Nyapin Ware (Chapters 6 and 7).

One form of decoration seen on Nyapin, Sumalo, and Aiser vessels—but very rarely on Wain vessels—is a red-clay wash, or "film," that was commonly applied to the outside (and less commonly also the inside) of pots prior to firing. Like Wain Ware pots before them, historic and modern pots made on Tumleo have not been given this type of decorative surface treatment. Instead, they have been blackened on the outside (see below), as documented by Erdweg (1902, p. 354) as well as May and Tuckson (1982, p. 315).

Historic and Modern Pottery Making

It has been said that there are three documented pottery-making techniques in use on the Sepik coast (Welsch & Terrell, 1998, pp. 61–63): paddle and anvil, spiral coiling, and slab building. However, as Christian Kaufmann (1999, pp. 33–34) has written, if you carefully observe Sepik potters at work by subdividing the creative process they use into steps, or phases—such as preparing the clay, building the body, shaping the body, and so on up to surface finishing

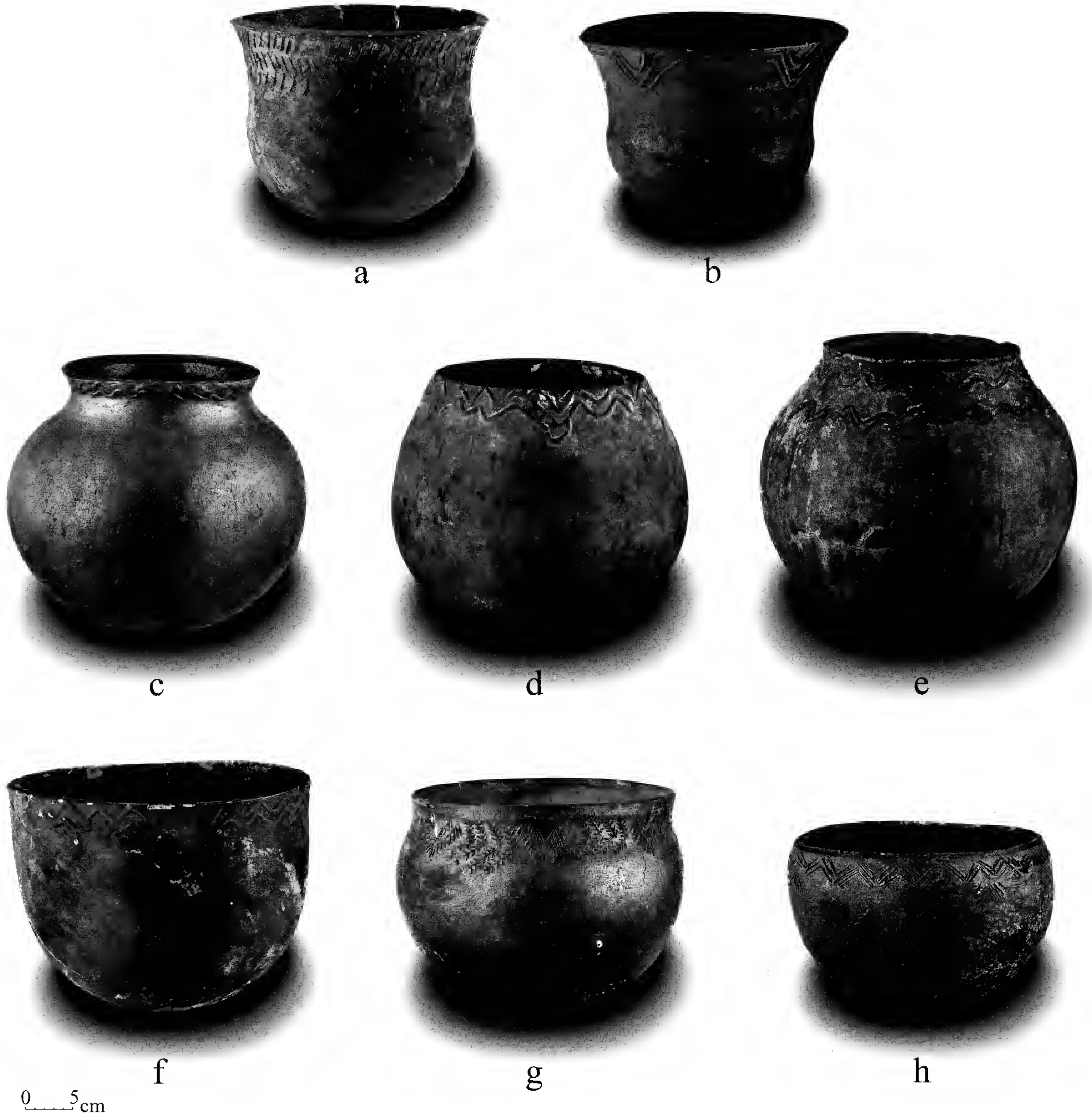


FIG. 8.8. Sago storage or sago stirring pots from Tumleo Island, Sepik coast, Papua New Guinea, photographed by John Weinstein: (**a**) FMNH no. 137891, A. B. Lewis Collection, 1909–1913, FMNH neg. no. A114498_01d; (**b**) no. 147902, Lewis Collection, A114528_01d; (**c**) no. 148970, George A. Dorsey Collection, 1908, A114509_03d; (**d**) no. 148971, Dorsey Collection, A114510_02d; (**e**) *sujanu*—for keeping sago—no. 137889, Lewis Collection, A114522_01d; (**f**) no. 148986, Dorsey Collection, A114530_02d; (**g**) *sal ahin*—for storing sago pudding—no. 250033, A. B. Lewis Project Expedition, 1993–1994, A114532_02d; (**h**) *sal*—cooking pot for stirring sago—made by Ropina Ewa of Sapi Village, no. 250038, Lewis Project Expedition, A114533_02d.

and decorating—then "you shall immediately see that you may get quite a mixture of technical processes that, looked at superficially only, could *seem* to be structurally opposed to each other, where in fact they are complementing eaeh other." In agreement with Kaufmann, I find that the information on Tumleo Island pottery making in the 20th century provided by different investigators at different times is basically all alike. However, in the following synopsis, I have noted some of the discrepancies reported as well as the commonalities.

According to May and Tuckson (1982, p. 15), paddle-and-anvil pots are locally made mostly by women and are round-based and full-bellied. They are light and fairly thin-walled. Since most of the prehistoric potsherds from the Sepik coast that we have studied are predominantly light and thin-walled, the paddle-and-anvil method may have been the favored technique of manufacture on the coast in the past as well. In any case, I have not been able to detect any convincing evidence of coiling or slab building as techniques in use in the past in the immediate Aitape area, although surface collections made in 1993 along the coast west of Aitape as far as the Indonesian border do show unambiguous evidence that coiling as a technique is and has been in use there (Chapter 5).

FIG. 8.9. Frying pan or lid for storage jar from Tumleo Island, Sepik coast, Papua New Guinea, photographed by John Weinstein: (**a**) *tapel*—used for food, especially sago—FMNH no. 137893, A. B. Lewis Collection, 1909–1913, FMNH neg. no. A114500_01d; (**b**) *tapel*, no. 137894, Lewis Collection, A114501_01d; (**c**) no. 148987, George A. Dorsey Collection, 1908, A114531_01d; (**d**) *tapel*, no. 137896, Lewis Collection, A114502_01d; (**e**) no. 146835, Capt. H. Voogdt Collection, 1906–1908, A114504_01d; (**f**) cover for cooking pot (*takum*)—from Sapi Village, made by Ana Ramoi—no. 250037, A. B. Lewis Project Expedition, 1993–1994, A114515_02d.

Obtaining the Clay Used in Historic and Modern Times

The documentary evidence available makes it clear that at least since the beginning of the 20th century, three locally recognized types of clay have been used by people on Tumleo Island for making pots, each type evidently from a different place or places either on Tumleo itself or on the nearby mainland.

According to Erdweg (1902, p. 350), these varieties of clay are locally called "red" (*peitj pei*), "black" (*peitj ngel*), and "white" (he gives no local name for this variety). However, he

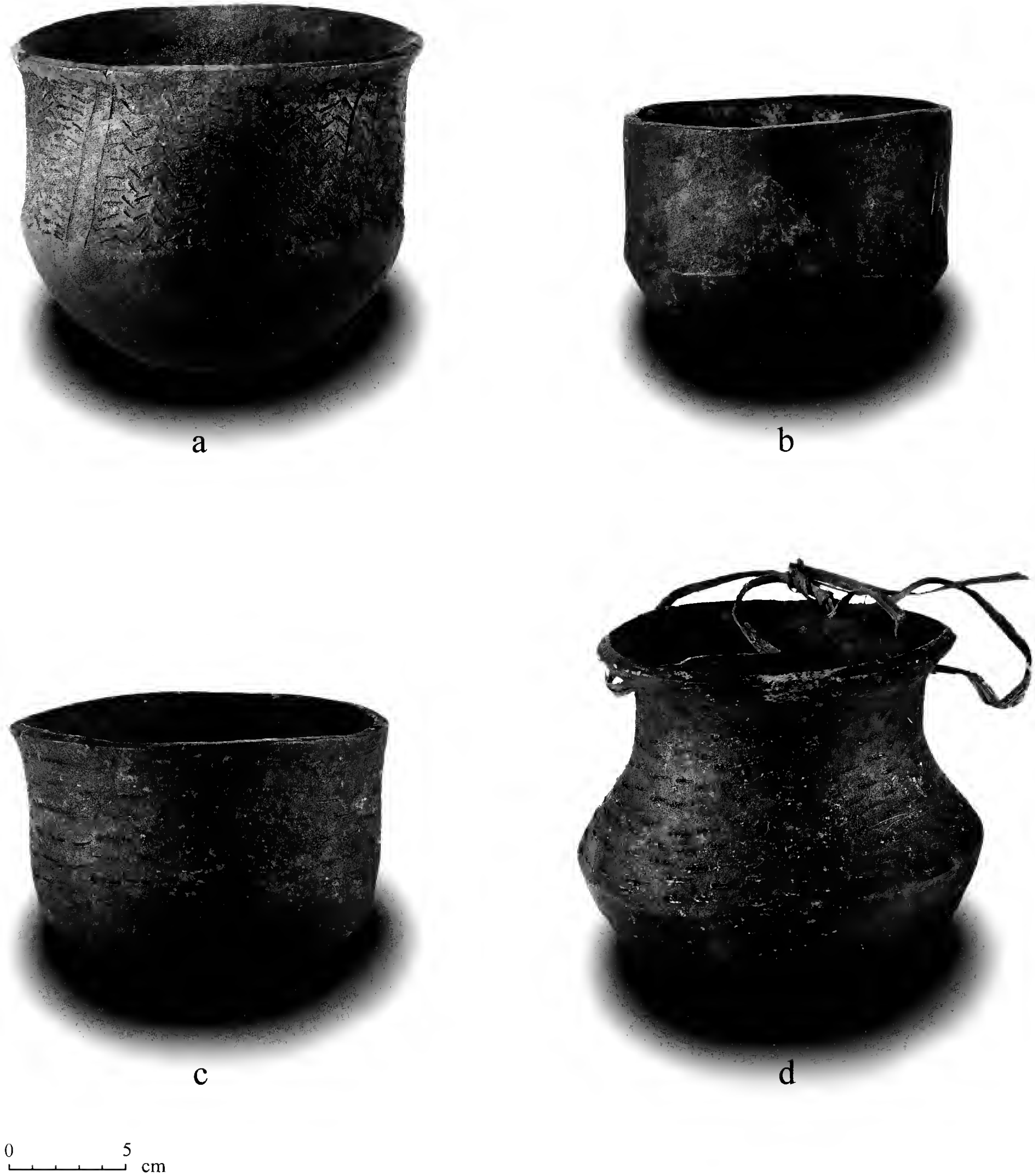


FIG. 8.10. Baby's washing pot from Tumleo Island, Sepik coast, Papua New Guinea, photographed by John Weinstein: (**a**) *takum*—small cooking pot for sago—FMNH no. 137897, A. B. Lewis Collection, 1909–1913, FMNH neg. no. A114499_01d; (**b**) no. 147892, Capt. H. Voogdt Collection, 1906–1908, A114506_01d; (**c**) no. 147901, Voogdt Collection, A114508_02d; (**d**) no. 148976, George A. Dorsey Collection, 1908, A114511_01d.

provides us with no information about how or why these three clays were seen locally as distinguishable in their composition and potting qualities, not just by their color. Importantly, Erdweg reports that such clays were to be found both on Tumleo and at Aitape on the mainland, although he indicates that it was uncommon then for Tumleo potters to go to Aitape to obtain clays from these mainland sources. As Erdweg describes them, these clays come from three different places on Tumleo: one type comes from a small trench at the foot of Ali Hill (referred to elsewhere in this monograph as "The Little Mountain") on the north side of the island (Chapter 13), another is a volcanic clay taken from the split rock of the hill itself, and a third is dug from clay deposits found at the foot of the hill. Unfortunately, Erdweg does not report which type comes from which place.

Unlike Erdweg, May and Tuckson (1982, p. 310) report that four, not just three, types of clay were in use on Tumleo in the 1970s. The first, a dark brown (*peitj njotj*) material, was obtained on the island as well as on the mainland near Aitape. In their estimation, this rough sandy "clay" should probably

FIG. 8.11. Miscellaneous pots from Tumleo Island, Sepik coast, Papua New Guinea, photographed by John Weinstein: (**a**) FMNH no. 146841, Capt. H. Voogdt Collection, 1906–1908, FMNH neg. no. A114505_01d; (**b**) no. 146834, Voogdt Collection, A114524_01d; (**c**) no. 146842, Voogdt Collection, A114632_0004d; (**d**) no. 146837, Voogdt Collection, A114634_003d; (**e**) no. 146849, Voogdt Collection, A114633_003d; (**f**) no. 147906, Voogdt Collection, A114529_02d; (**g**) no. 137901, A. B. Lewis Collection, 1909–1913, A114635_004d; (**h**) no. 137888, Lewis Collection, A114637_006d; (**i**) FMNH 137887, Lewis Collection, A114638_004d; (**j**) no. 147899, Voogdt Collection, A114527_01d.

be classed as a temper rather than as a clay. The second type (*peitj raiy*) of the four ingredients—and in their estimation the principal clay ingredient—was also brown in appearance, although it was locally referred to as being red in color. This clay was usually obtained, they report, on the mainland at a source or sources not far from Raihu hamlet on the east side of Aitape. The third ingredient (*peitj rarun*), which they again see as more a tempering material than a true clay, was light yellowish brown gray in color. The fourth, May and Tuckson say, was an optional ingredient—something called *peitj rien*, which was composed mostly of limestone and weathered rock—that was used only sparingly. This last ingredient evidently could be found, they report, both on the island and on the mainland.

In the 1990s, Rob Welsch and John Terrell obtained additional information about pottery making on Tumleo. Three types of clay, they report, were used then to manufacture pottery on the island: a clay described as like "flour" (*paic* *trarun*), a "black" clay (*paic nuwaic*) obtained both on the island and on the mainland, and a "red" clay (*paic pai*) found only on the mainland.

Therefore, while the orthography and descriptive terms used by these several commentators differ somewhat, all three of these historic eyewitness sources concur that potters on Tumleo during the 20th century favored using a blend of at least three locally available clays, each seen as different in color and evidently also in potting characteristics.

Preparation of the Clay

Erdweg (1902, p. 351) says that after clay was brought home from the hill on the northern side of the island, it was handled in three possible ways: if it was to be used right away, it was put directly into a form made from a broken canoe board; if it was to be used a short while later, it was stored in baskets until needed; for longer storage, it was mixed with seawater, worked into a lump, and then stored under the potter's house.

To prepare clay for pot making, the raw material was picked through to get rid of stones, and then put out to dry in the sun. Eventually, using a smooth, round stone, it was pounded into small pieces and cleared of any additional stones and foreign matter. Finally, it was put through a cone-shaped sieve. The sieved material was mixed with seawater, kneaded until it was smooth, and pounded into useful lumps.

According to May and Tuckson, preparing the raw materials used in pottery making is much more elaborate in the Aitape area than anywhere else in New Guinea they visited when they were doing their field research in the 1970s. Furthermore, potters in this area use a special kind of basketry sieve—a processing tool they observed in use nowhere else. They add that such cane sieves were also used to process sago flour and coconut milk, and that today wire sieves on metal frames are frequently used by Tumleo potters for these purposes.

May and Tuckson (1982, pp. 310–311) also report that after being dried, the brown and red clays were mixed together in a ratio of about one part brown to five parts red, and then the sieve was used to agitate the blended ingredients in a 44-gallon metal drum filled with water. After this, *peitj rarun* was also sun-dried, pounded, and dry-sieved into a separate container. About one week before potting clay was needed, some of the wet mixture of brown and red clays was taken from the drum and poured into an old clay pot to dry out enough to become firmer. When ready, a layer of *petit rarun*, approximately 2 cm thick, was sprinkled on a wooden board, followed by a 10-cm-thick layer of the wet clay mixture. The mixture was then kneaded with the fingers, and more temper, *petit rarun*, was added until the mixture was felt to be of the right consistency. If needed (they do not say why), the fourth ingredient, *pietj rien*, was worked in with the temper. Finally, the mixture was divided into lumps of approximately 3 kg that were individually kneaded, thumped on the board, and patted into elongated balls.

Shaping of the Vessels

According to Erdweg (1902, pp. 351–352), a fairly wet lump of clay, about the size of a child's head, was placed on a large old potsherd. Using a wooden beater, the potter—apparently always a woman in this part of New Guinea—shaped the clay mass into a cylindrical form, and then, using an egg-shaped stone, she would make a hollow in the middle of the clay mass—pounding the cavity lightly with the stone to make it deeper. After it was judged to be of the proper size, the potter would use her hands to rough out a container about two liters in volume (as observed by Erdweg). The inside of the rough pot was then smoothed with moistened fingers and set aside to dry out of the sun.

This shaping process was also observed by Lewis (Welsch, 1998, p. 84) as well as by May and Tuckson (1982, pp. 311–312). The latter add that before setting a pot-to-be aside to dry for half a day or overnight, its rim was either shaped by tapping it to flatten and consolidate it or trimmed off with a strip of coconut fiber or wire, and then tapped to finish it. While the details need not be repeated here, Erdweg (1902, p. 352), as well as May and Tuckson (1982, pp. 312–314), alike report in some detail on how potters further shaped, trimmed, and decorated the pots they were making before setting them aside to dry out completely before firing.

It should be noted that Richard Parkinson (1979, pp. 78–82) has described pottery making on Tumleo somewhat differently. It may be that he saw a guild of potters at work on the island different from those witnessed by these other observers.

Firing Techniques

Erdweg (1902, pp. 353–354) and May and Tuckson (1982, p. 314) report that coconut fronds were normally used for firing. A few coconut leaves were burned inside the pot and rubbed outside to warm up the clay so that the heat would be evenly distributed. The vessels to be fired were next placed alongside one another with a space in between. Coconut fronds were put in a layer on and between them, and lit. The potter stood next to the fire holding two long sticks as tongs to turn the vessels and distribute the hot coals around the pots to ensure that they were being evenly heated. The process of firing was over in about one to one and a half hours. While the details differ slightly, all commentators report that as a final step, pots were normally blackened over a small fire of coconut leaves and then sealed with a solution of sago starch. It is assumed that this was done to produce a decorative effect.

Conclusions

Historic and modern pots from the Aitape area in the collections at the Museum were studied to explore three interrelated questions:

Do their shapes resemble those of prehistoric pots in this part of New Guinea, and, if so, what are they known to have been used for? I have shown that there is continuity in vessel shape from prehistoric times to the present, although there are both ancient and modern forms that stand out, too, as exceptions to this general rule. Round pots with inverted and everted rims predominate at all times, as do bowls with open rims. Large, thick-walled pots are found among the historic vessels, but thick-walled vessels were evidently rare in the past before Wain Ware pots came into fashion (see Chapter 7). Ceramic platters were evidently limited to the wares we have called Nyapin and Sumalo, and are absent in the Museum's historic and modern holdings. While there is currently no specific evidence for vessel use in prehistoric times, most of the prehistoric vessels may have been used for domestic purposes (e.g., food storage and cooking).

Is there design continuity? One of the most distinctive design elements seen in the prehistoric Aitape sequence, the "eye" motif, is not seen (at least in recognizable form) on historic and modern vessels, but a variant of this motif was still being carved around the exterior (i.e., reverse) rims of wooden platters made on the Sepik coast during the 20th century. Nonetheless, it is now apparent that while the Aitape ceramic sequence can be subdivided stylistically into an evolving series of four distinctive wares (Chapter 7), the only major design break, or discontinuity, occurred after World War II. Designs incised on pots collected for the Museum in the 1990s are highly variable and seemingly idiosyncratic, and cannot be readily interpreted as modern variants on older decorative themes.

What can historic and modern pottery-making techniques on Tumleo Island tell us about prehistoric techniques? All those who have described modern pottery making on Tumleo emphasize how several different clays are combined to produce a pot. In addition, LA-ICP-MS analysis (Chapter 13) of prehistoric pottery made on the Aitape coast and on Tumleo shows that mixtures of clays were also used to manufacture local prehistoric wares. Summerhayes and Allen (2007) say that early colonizers in New Guinea used different combinations of clays to produce early Lapita pottery, although single clay-and-filler mixtures were used locally in manufacturing later Lapita ceramics. Therefore, we can say that using elaborate preparations of clays is a tradition that is still being followed in this area today, and was and is the culturally proper way of making a pot. It may be that other techniques used today in pottery making may hearken back into the past as well.

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Chapter 9: Wooden Platters and Bowls in the Ethnographic Collections

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Abstract

Judging by the ethnographic collections at the Field Museum of Natural History, ceramic and wooden platters and shallow open bowls on the Sepik coast are not just analogous types of objects, but are alike derived historically from Lapita prototypes. Archaeological and ethnographic evidence from the Sepik coast documents the evident survival in the western Pacific of a stylized symbol or motif—the so-called Lapita face—on pottery and possibly other kinds of material items (such as wooden bowls and serving platters) for at least 3,300 years.

Introduction

During laboratory study of ceramic finds from 1993 and 1996, Esther Schechter and I realized that some of the sherds we were examining in the wares we call Nyapin and Sumalo came from shallow dishes and flat plates or platters (Fig. 9.1a, c, d). Analogous ceramic bowls and flat-bottomed dishes, trays, or platters, with or without pedestals, occur in Lapita ceramic assemblages (Kirch, 2000, pp. 102, 104; Best, 2002, p. 73; Spriggs, 2002; see Fig. 9.1b). While there are no ethnographic ceramic platters in the Pacific collections at the Field Museum of Natural History, we knew we did have wooden platters and shallow wooden bowls from the Sepik coast. When we looked at them, we found that they commonly have designs carved on them that closely resemble designs on prehistoric Wain Ware in the Aitape area (Fig. 9.2).

Having found this apparent expressive, or symbolic, continuity down through time and across wares and media, we extended our laboratory work to include a study of wooden platters and bowls not only from the Pacific, but also from Madagascar (because of its linguistic ties to the Pacific region as an Austronesian-speaking country). We wanted to see how reasonable it would be to infer that ceramic and wooden platters and shallow open bowls on the Sepik coast are not just analogous types of objects, but are in truth alike derived historically from early Lapita prototypes.

Field Museum's Ethnographic Collections

There are at least 1,068 wooden platters and bowls in the ethnographic collections from the Pacific Islands at the Museum (Table 9.1). We say "at least" because both these forms are vernacular types or categories, and whether a given object should be classified as such is not always an easy decision to make.

Geographic Distribution

While wooden bowls of many different sizes, shapes, and varieties are common in Oceania (as they are elsewhere), flat or nearly flat platters are quite restricted in their geographic distribution in this part of the world (Fig. 9.3; Table 9.1). Only about 10% (n = 110) of the items we studied would conventionally be described in English as platters. Almost 80% of these come from Papua New Guinea. Furthermore, over 90% (n = 80) of them are documented as having been collected along the north coast of New Guinea and on the smaller nearby offshore islands.

Thus, while it might seem improbable that the presence or absence in museum ethnographic collections of such a seemingly mundane object as a carved wooden plate or platter would be historically informative, the restricted geographic distribution of these items in the Pacific (judging by the Museum's collections) hints that the opposite conclusion may be nearer the truth. If so, then how likely is it that shallow or flat-bottomed Lapita dishes, Nyapin and

Table 9.1. Wooden bowls and platters in the ethnographic collections from the Pacific Islands and Madagascar at the Field Museum of Natural History.

Geographic location	Total no. of objects	Objects coded as platters
Total sample	1,068	110
Papua New Guinea	719	87
Vanuatu	26	11
Other Pacific and Madagascar	323	12

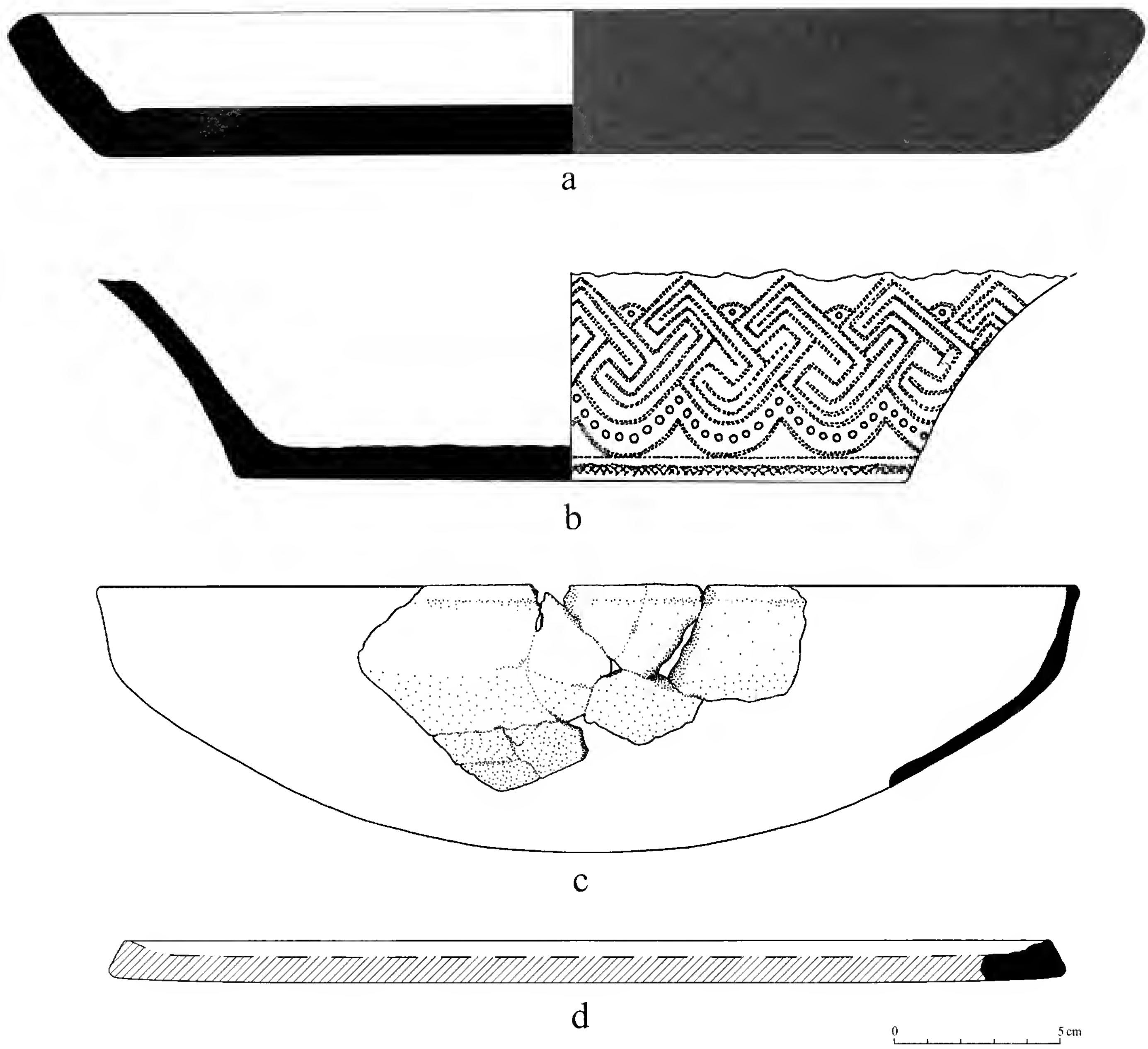

FIG. 9.1. Reconstructed Sumalo Ware ceramic platters and a shallow open bowl compared with a flat-bottomed Lapita dish or platter: (**a**) reconstructed platter from Tumleo Island (NGRP 46 1A/3/1); (**b**) reconstructed Lapita flat-bottomed vessel (reprinted by permission, courtesy of Christophe Sand); (**c**) reconstructed open bowl from Aitape (NGRP 23 2A/C/1); (**d**) reconstructed flat ceramic platter from Tumleo Island (NGRP 46 2/2/1).

Sumalo pottery trays and shallow bowls, and recent and contemporary wooden platters and open shallow bowls from northern New Guinea make up a homologous (i.e., historically related) set of objects?

Distinguishing Characteristics

Little in the way of conjecture is needed to see that certain designs carved on wooden platters and shallow bowls collected along the northern shores of New Guinea are identical, or nearly so, to designs used on late prehistoric pottery in the Aitape area (Fig. 9.2). However, these historic and modern items also have other distinguishing characteristics that set them apart as a distinct class of things within the available ethnographic sample of 297 comparable objects in the Museum's holdings from this area of New Guinea (Table 9.2).

Shape

There are two basic object forms of interest within the geographic range shown in Figure 9.3. Between Sissano Lagoon west of Aitape and the offshore islands of Walis (Walifu) and Tarawai (Tandanye), many wooden dishes are easily classifiable as flat-bottomed platters that are more or less oval in shape (Figs. 9.4, 9.15–9.20, and 9.23). In the Walis-Tarawai area, however, another shape—what most English speakers would probably identify as a shallow round bowl—is popular, a shape that then predominates for some distance farther to the east (Figs. 9.5, 9.6, 9.21, 9.22, and 9.24–9.30). In the collections at the Museum for Walis Island, there are also two items that could be called transitional in shape: both are shallow bowls that are oval in appearance (Figs. 9.15 and 9.31).

It is worth repeating, however, that these basic vessel forms are vernacular categories. On the evidence examined, the generalization that would appear to make most sense would be that in the Aitape area of the Sepik coast, people have preferred making wooden dishes that are oval and flat with narrow, rounded, and upward-flaring rims, while in the Wewak area (Walis-Tarawai and mainland communities), as well as places farther to the east, the preferred shape has been the shallow round bowl. This having been said, it should be stressed that both types exhibit the following shared decorative commonalities.

Side Lugs

In addition to shape (and perhaps, therefore, function), another design characteristic—the presence of small carved handles or ledgelike narrow lugs on the sides of these wooden

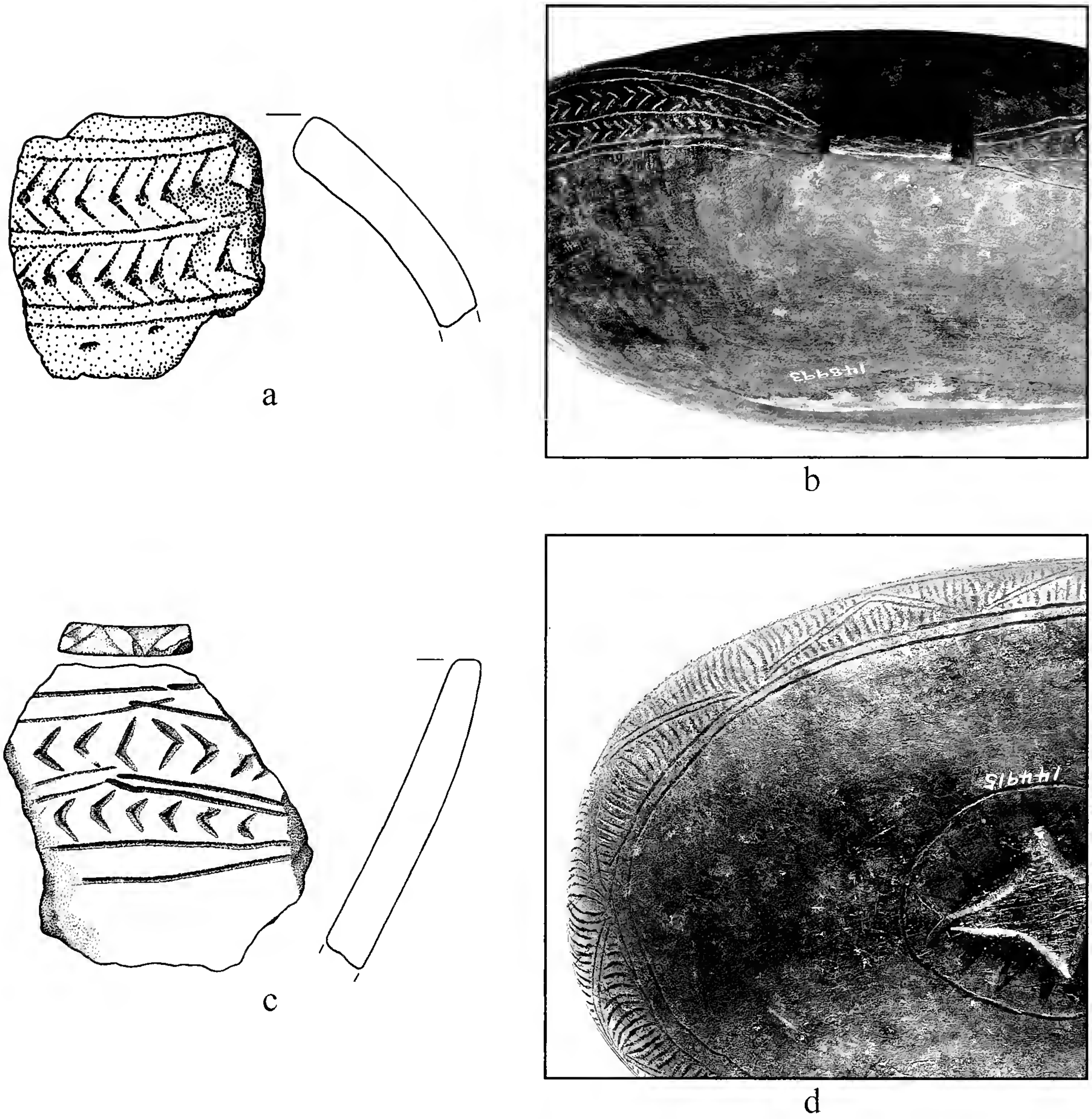

FIG. 9.2. Wain Ware rim sherds from Tumleo Island compared with carved wooden platters (not to scale); (**b**) from Angel Island (FMNH no. 148993, George A. Dorsey Collection, 1908); and (**d**) from Seleo Island (no. 144915, Umlauff [Voogdt] Collection, 1908–1912; FMNH neg. no. A114369).

platters and bowls—may also be historically significant (Tables 9.3 and 9.4; Fig. 9.4).

These modest and seemingly non-functional lugs are usually aligned directly opposite one another below the outer rim or edge—sometimes well below the edge. In the case of platters, which are almost always oval in appearance, they are positioned in the middle of the two longer sides. On both platters and bowls, one of the lugs normally has two holes or perforations bored through the wood adjacent to one another; the other lug in the pair is almost always unperforated (Fig. 9.4).

It seems unlikely that these little lugs are handles in a conventionally useful way. While it might be argued that the one lug in each pair having two perforations could serve together with a length of twine as a convenient way to hang up the object in question when not in use, this reasoning does not account for why anyone would bother to whittle so fastidiously the second (seemingly) useless lug in the pair. Instead, it seems likely that these lugs are mostly symbolic in purpose rather than primarily utilitarian. It is our working hypothesis that the lug with perforations may represent the eyes of some creature (mythical or otherwise), while the opposing (but not perforated) lug may be the creature's nose (Terrell & Schechter, 2007). If this explanation sounds far-fetched, consider the mute testimony of two wooden bowls from the Sepik coast entirely in keeping with this interpretation (Figs. 9.5–9.7). (Note also that these bowls may have not just one but two creatures represented on them, an observation I will return to.)

Rim Decoration

The Sepik wooden platters and bowls with side lugs at the Museum normally also have one or more bands of decoration incised around the outer edge directly below the lip. As shown in Figures 9.8–9.13, the work done usually begins and ends at the paired side lugs, although there are rare exceptions to this rule (e.g., Fig. 9.14).

When this type of decoration is absent, the band or zone where it generally occurs is nonetheless usually marked or emphasized in some fashion (Figs. 9.5 and 9.6). All the platters in our collections having both traits (side lugs and rim

Table 9.2. The total sample of carved wooden bowls, platters, etc. of various shapes and types from the north coast of Papua New Guinea examined at the Museum.

Locality	No. of items
Vanimo	2
Aitape	105
Yakamul	4
Dallmannhafen	83
Sepik	24
Isumrud Strait	40
Schouten Islands	12
Astrolabe Bay	13
Stephan Strait	14
Total	**297**

decoration) are from communities on the Sepik coast; 52 out of 56 of the bowls similarly adorned are also identified in the Museum's records as coming from this area (for the rest, the provenance attribution is uncertain).

When we began piecing together a ceramic sequence for the Aitape area, we initially assumed that painting, incising, impressing, or applying designs to pottery had been chiefly decorative. After we saw that some of the earliest pottery designs may be stylized representations of eyes and faces (Chapter 7), we considered whether more recent design motifs might also be symbolic in intent. Thus, for instance, it requires little imagination to see a motif common to both prehistoric Wain pottery and historic and modern wooden items as possibly an abstract way of drawing eyes using opposed parenthesis-like and herringbone design elements (Figs. 9.2, 9.8–9.10, 9.12–9.14, and 9.32–9.33):

(a) <<<(())>>>   (b) <<<<>>>>

Central Medallion

The presence of a central carved motif or design medallion on the underside of wooden platters and shallow bowls from northern New Guinea is another characteristic that clearly defines such objects as a distinctive class of things. While the medallion motif varies, it is nearly always rendered in bas-relief; it is not solely an incised feature. Exactly what is being portrayed is generally difficult to say. Sometimes the motif would seem to be a four-sided star (Figs. 9.15–9.18, and 9.31); a fish or other animal (Fig. 9.19), what might be described as nested star (Fig. 9.20); or a circle or a set of nested concentric circles (Figs. 9.21 and 9.30), but at other times, the design is

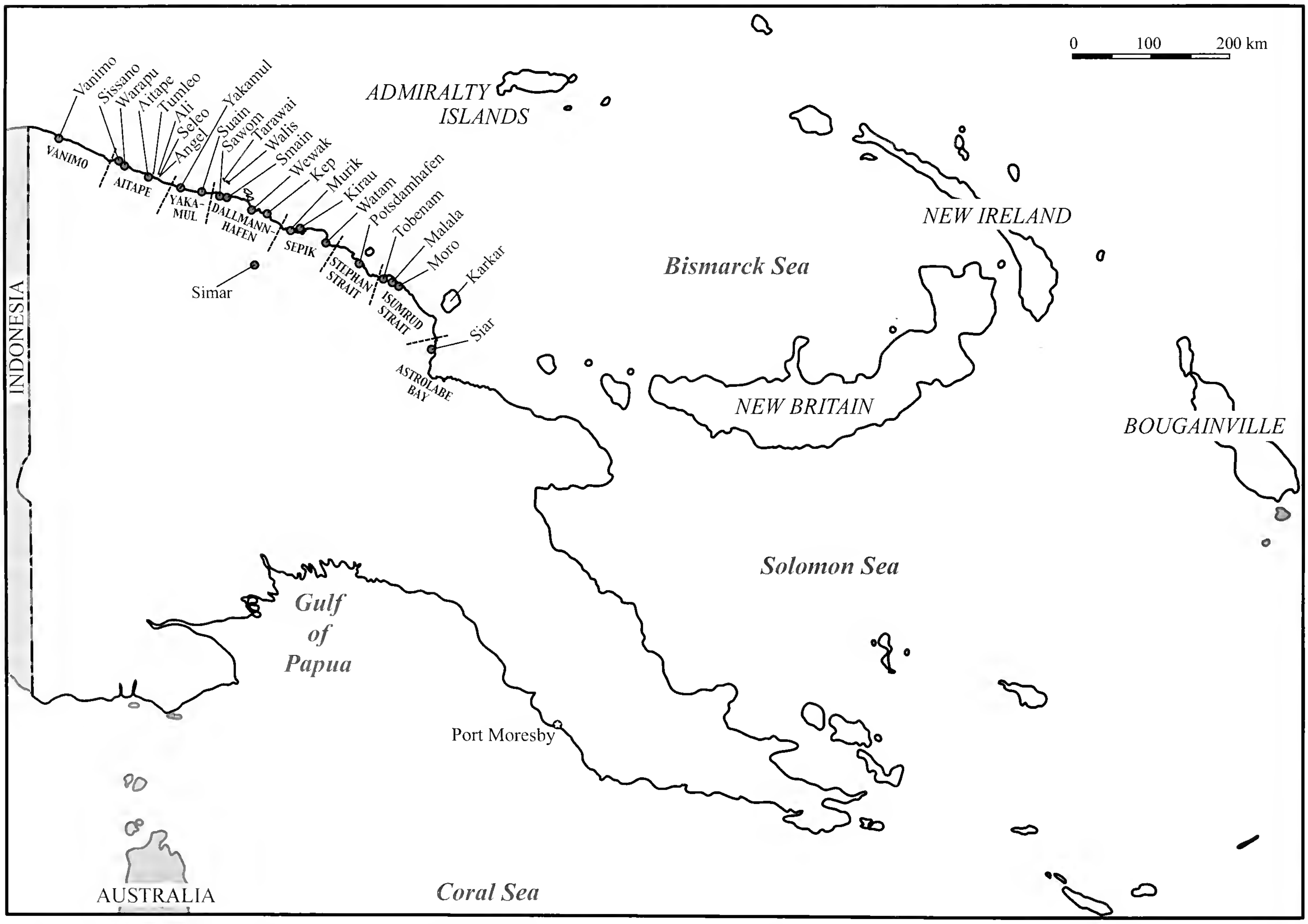

Fig. 9.3. The geographic distribution of wooden platters and bowls with side lugs and border decoration (see Table 9.4) in the Pacific collections at the Field Museum of Natural History.

FIG. 9.4. Wooden platter with side lugs and border decoration from Sissano (FMNH no. 144977, Umlauff [Voogdt] Collection, 1910–1912; FMNH neg. no. A114370).

either strangely formed (Figs. 9.22, 9.23, and 9.31), or intricate but esoteric (Figs. 9.24–9.29).

Discussion

Based on what we have heard from people on the Sepik coast, as well as on scattered remarks in the ethnographic literature (e.g., Mead, 1938, p. 159), wooden bowls and platters such as these are serving dishes used mostly on special occasions. Nothing is known about how Lapita shallow dishes and flat-bottomed platters were used, but it is not far-fetched to think they, too, were serving dishes to be used on particular occasions.

TABLE 9.3. Observed trait correlations between geography, paired side lugs, and border decoration on wooden bowls and platters.

Papua New Guinea wooden platters, bowls, etc.	Platters	Other
Total sample from Papua New Guinea	87	632
Total number with carved side lugs	73	188
With both lugs + border decoration	53	56
With lugs + border decoration + Sepik area	53	52

TABLE 9.4. Villages where the platters and shallow open wooden bowls from the Sepik coast in the collections were obtained (see Fig. 9.4); these place names are contemporary and are not necessarily those of present-day communities.

Location	Platters	Bowls
Sissano	1	0
Warapu	0	1
Ali	7	3
Angel	6	3
Tumleo	2	0
Seleo	3	1
Suain	1	0
Tarawai	17	12
Walis	9	4
Sawom	1	0
Smain	3	1
Wewak	0	4
Kep	2	0
Simar	0	1
Murik	0	1
Kirau	0	7
Watam	0	3
Bure	0	3
Potsdamhafen	0	2
Tobenam	0	1
Malala	0	1
Moro	0	1
Karkar	0	5
Siar	0	2
Totals	**52**	**56**

FIG. 9.5. Wooden bowl or platter from Walis Island (FMNH no. 147526, George A. Dorsey Collection, 1908; FMNH neg. no. A114372).

On first encounter, there would seem to be little beyond this plausible similarity in vessel form and possible function that might be taken to link wooden platters and bowls on the Sepik coast with either prehistoric Lapita vessel types elsewhere in the Pacific or Nyapin and Sumalo ceramic prototypes at Aitape. Certainly we know of no specific prehistoric parallels for the central medallions on the underside, or reverse, of these historic and modern Sepik items. Without repeating in detail an argument already published (Terrell & Schechter, 2007), a case can be built for saying that such things, like their Nyapin and Sumalo antecedents, are derived historically from Lapita prototypes if due consideration is given to other features that distinguish them from comparable things made elsewhere in New Guinea and the Pacific.

Earlier in this chapter, I noted parenthetically that some of these platters and bowls arguably have more than one creature represented on them: one rendered in a fairly naturalistic way, the other more cryptically expressed (e.g., Figs. 9.5, 9.6, and 9.24–9.26). Note, for instance, four seemingly atypical features of the bowl shown in Figure 9.25. While the decorative band around the rim of this bowl is clearly demarcated, the band has been left entirely plain—that is, it has not been incised with a design of any sort. Second, there is just one lug, and instead of having the usual two perforations, the single lug has been carefully shaped into a tiny wooden strap, or loop. Additionally, the design field between the ornate central medallion and the plain band around the rim has been used to portray a turtle in an unambiguously naturalistic fashion. Fourth and most puzzling of all, three little projecting bumps, or nubbins, have been meticulously carved: two between the rear legs of the turtle and one just in front of its nose. While inferential, we think that the rim band was left plain by the carver of this bowl because, rather than incising a design there alluding to or referencing something, he instead opted to carve that something in a most realistic fashion—namely, a turtle. Similarly, while wanting to provide for a way to hang the bowl up for safekeeping (or for some other reason), he did not want to whittle out a pair of standard lugs. Instead, he opted to carve small nubbins similarly referencing the eyes of the other creature conventionally included on such platters and bowls.

Noting these details is worthwhile because it is well known that the faces of two creatures were sometimes drawn on

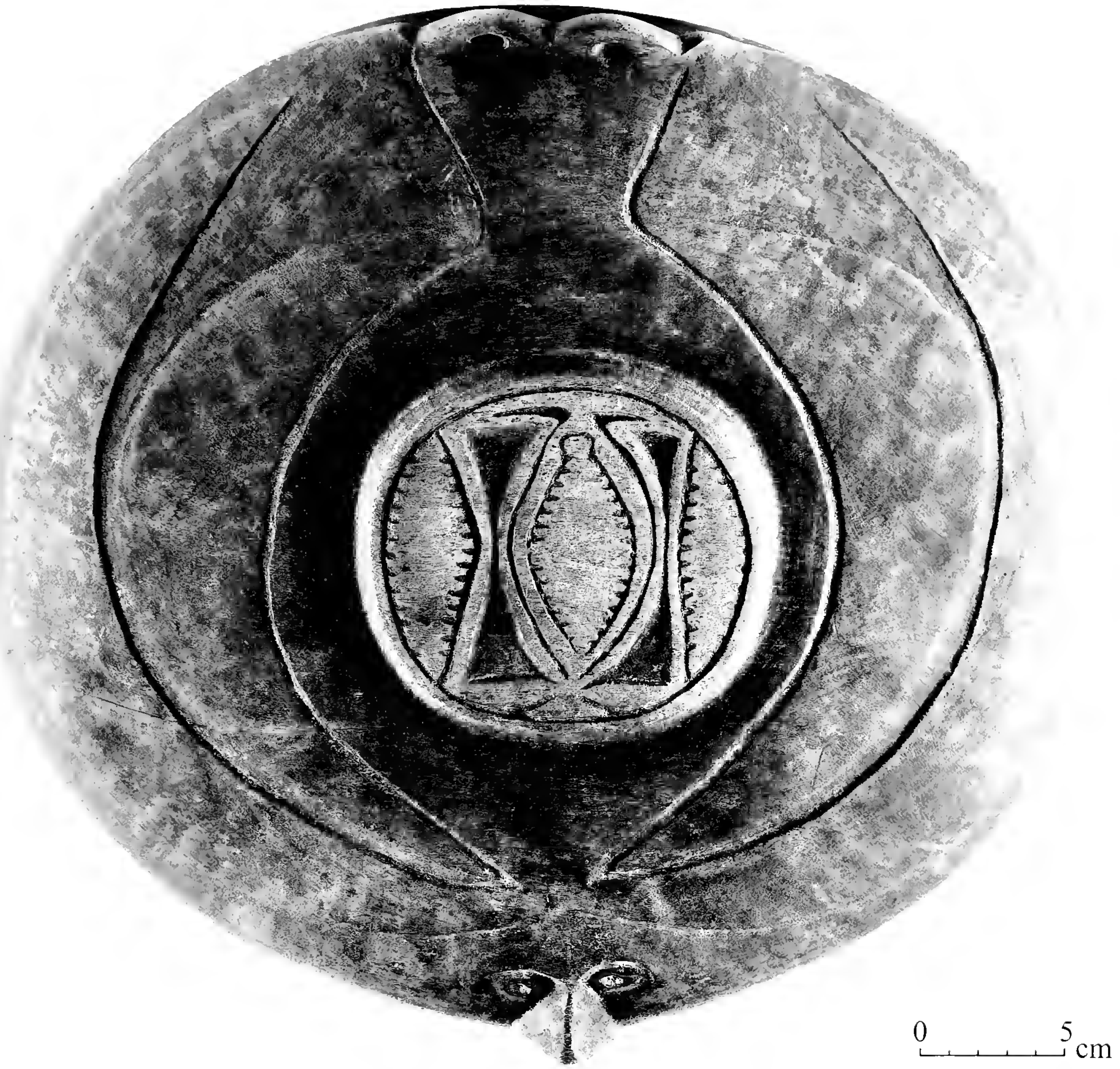

FIG. 9.6. Wooden bowl or platter from Kirau (FMNH no. 140722, A. B. Lewis Collection, 1909–1913; FMNH neg. no. A114430).

Lapita pottery vessels, and it can be argued that one of these creatures is a human being (or humanlike creature), while the other is a turtle (Terrell & Schechter, 2007, p. 77). Again, there is no need to repeat the details of our published argument, but I want to emphasize that claiming resemblances between historic and modern Sepik dishes and prehistoric Lapita, Nyapin, and Sumalo ceramic prototypes are homologous—and not just accidental or analogous—is founded on more than finding plausible parallels in vessel form and (possible) function. While the reasoning behind this statement can be found elsewhere (Terrell & Schechter, 2007), one further detail should be included here. The design or motif conventionally carved around the rim of Sepik platters and bowls is not only of interest because it also occurs on late prehistoric Wain Ware at Aitape. As shown in Figure 9.34, this particular design is more than aesthetically appealing. It requires no great leap of faith to infer that this motif is a coded way of alluding to sea turtles, specifically the Green sea turtle (*Chelonia mydas*).

This having been said, it should be added that the platters in Figures 9.29–9.31 show that sometimes dishes may have animals other than turtles carved in some manner on them—for instance, a flying fox (i.e., fruit bats of the genus *Pteropus*). When this is the case, the dishes also differ in other specific details from those described in this chapter. The probable reason for such deviation from what was considered standard and usual elsewhere may have been simply that while those doing the carving may have agreed with their neighbors that certain kinds of meals call for special dishes, they wanted to express something new or different from what others were accustomed to "saying" through the iconography chosen to adorn them.

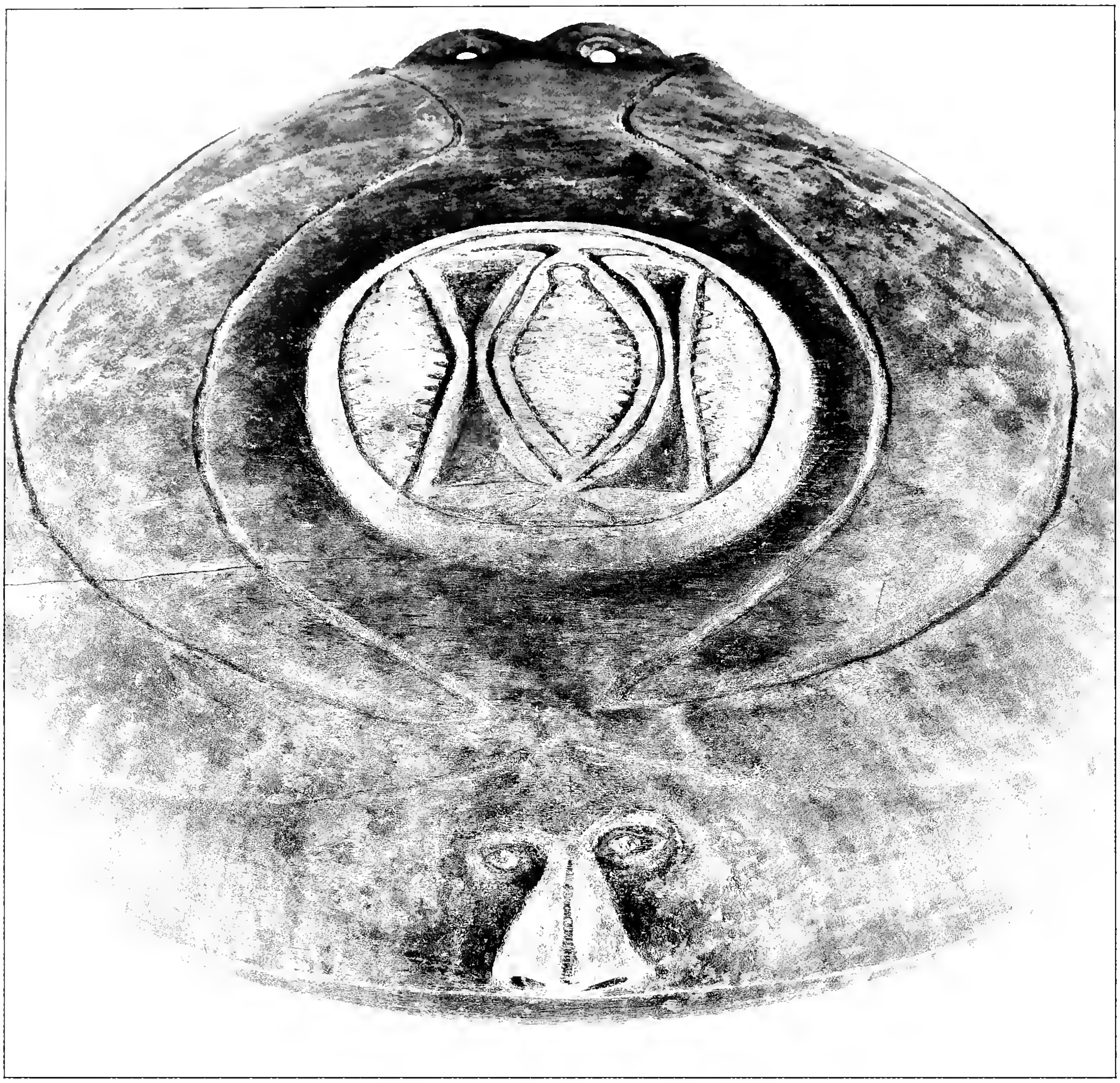

Fig. 9.7. Detail of Figure 9.6.

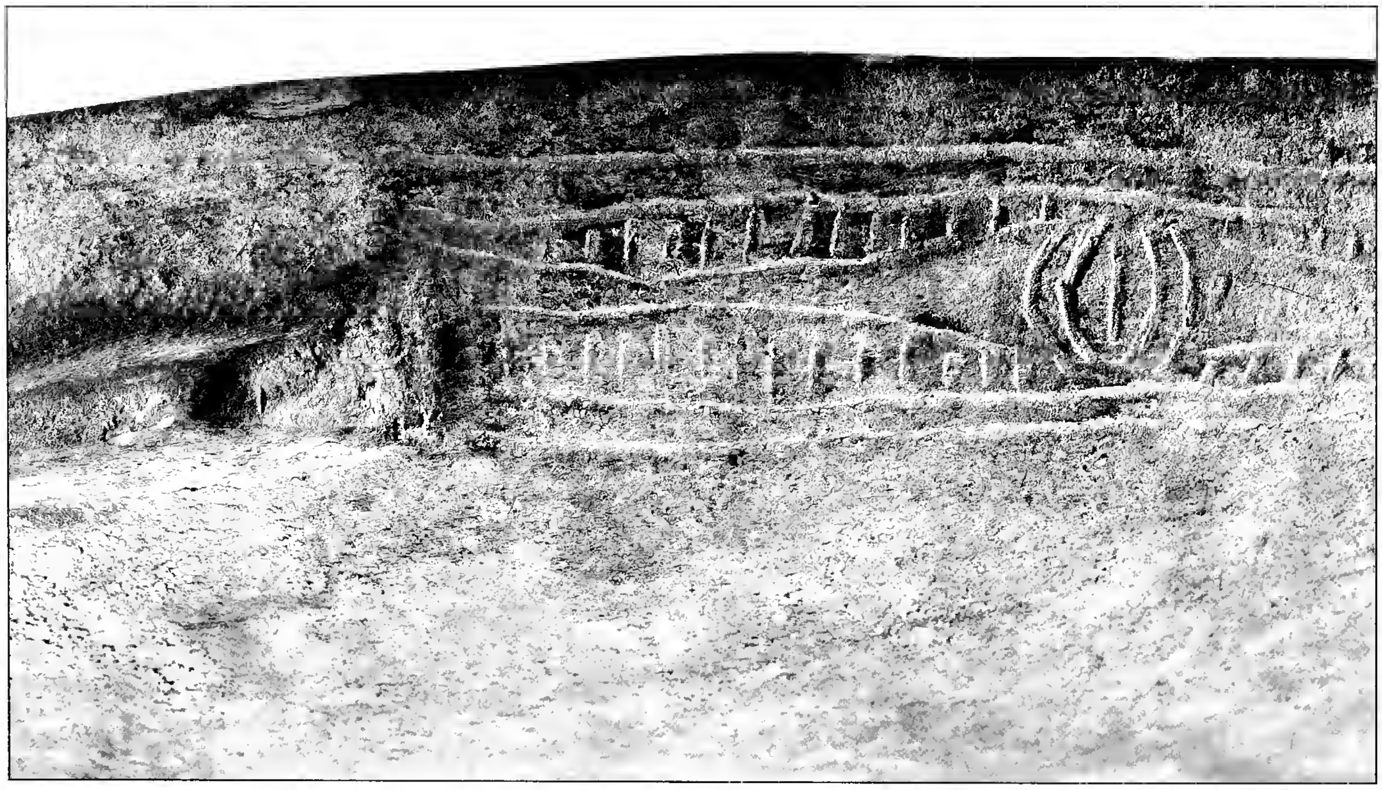

Fig. 9.8. Detail showing the carving on a wooden bowl or platter from Walifu (Walis) Island (FMNH no. 148511, George A. Dorsey Collection, 1908; FMNH neg. no. A114431).

Fig. 9.9. Detail showing the carving on a wooden bowl or platter from Angel Island (FMNH no. 148999, George A. Dorsey Collection, 1908; FMNH neg. no. A114377).

Fig. 9.10. Detail showing the carving on a wooden bowl or platter from Suain; made by Demien Dan (FMNH no. 249916, Welsch, Oltomo, Terrell Collection, 1993–1994; FMNH neg. no. A114379).

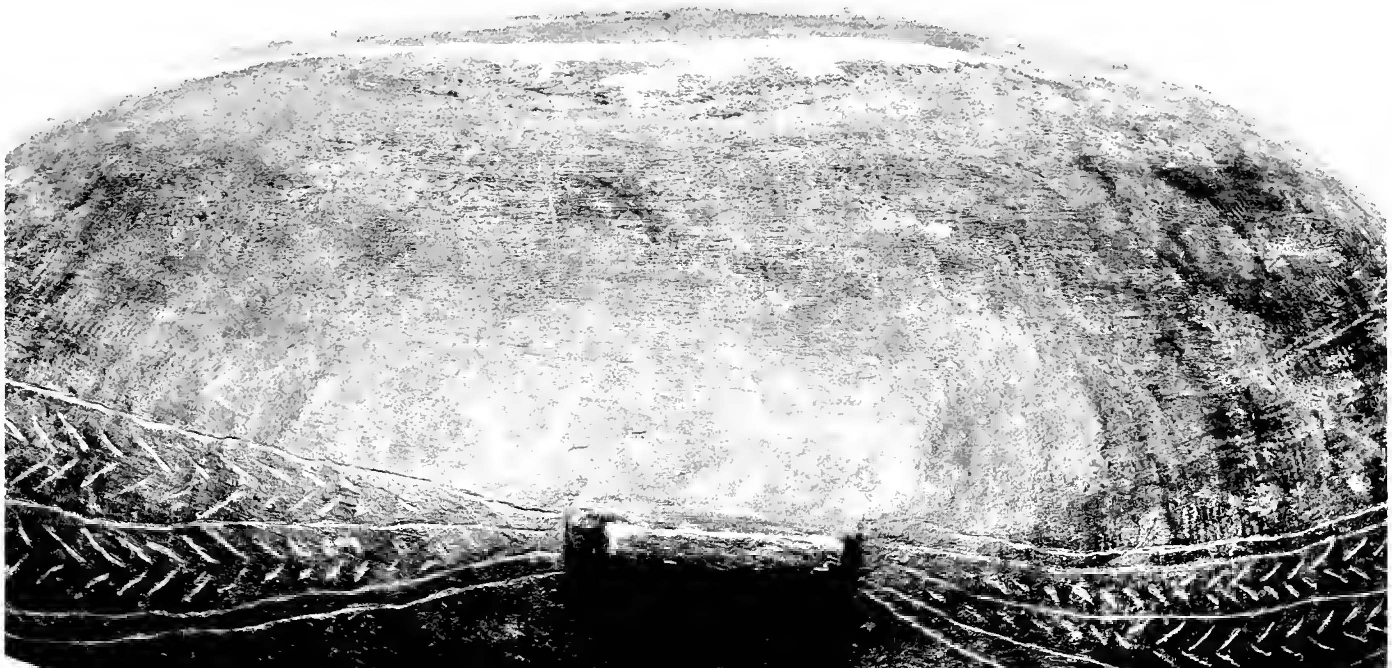

Fig. 9.11. Detail showing the carving on a shallow wooden bowl from Angel Island (FMNH no. 148993, George A. Dorsey Collection, 1908; FMNH neg. no. A114376).

FIG. 9.12. Detail showing the carving on a wooden platter from Sissano (FMNH no. 144977, Voogdt and others Collection, 1913; FMNH neg. no. A114370).

FIG. 9.13. Detail showing the carving on a wooden bowl or platter from Angel Island (FMNH no. 249772, Welsch, Oltomo, Terrell Collection 1993–1994; FMNH neg. no. A114378).

FIG. 9.14. Detail showing the carving on a wooden bowl or platter from Seleo Island (FMNH no. 148831, George A. Dorsey Collection, 1908; FMNH neg. no. A114375).

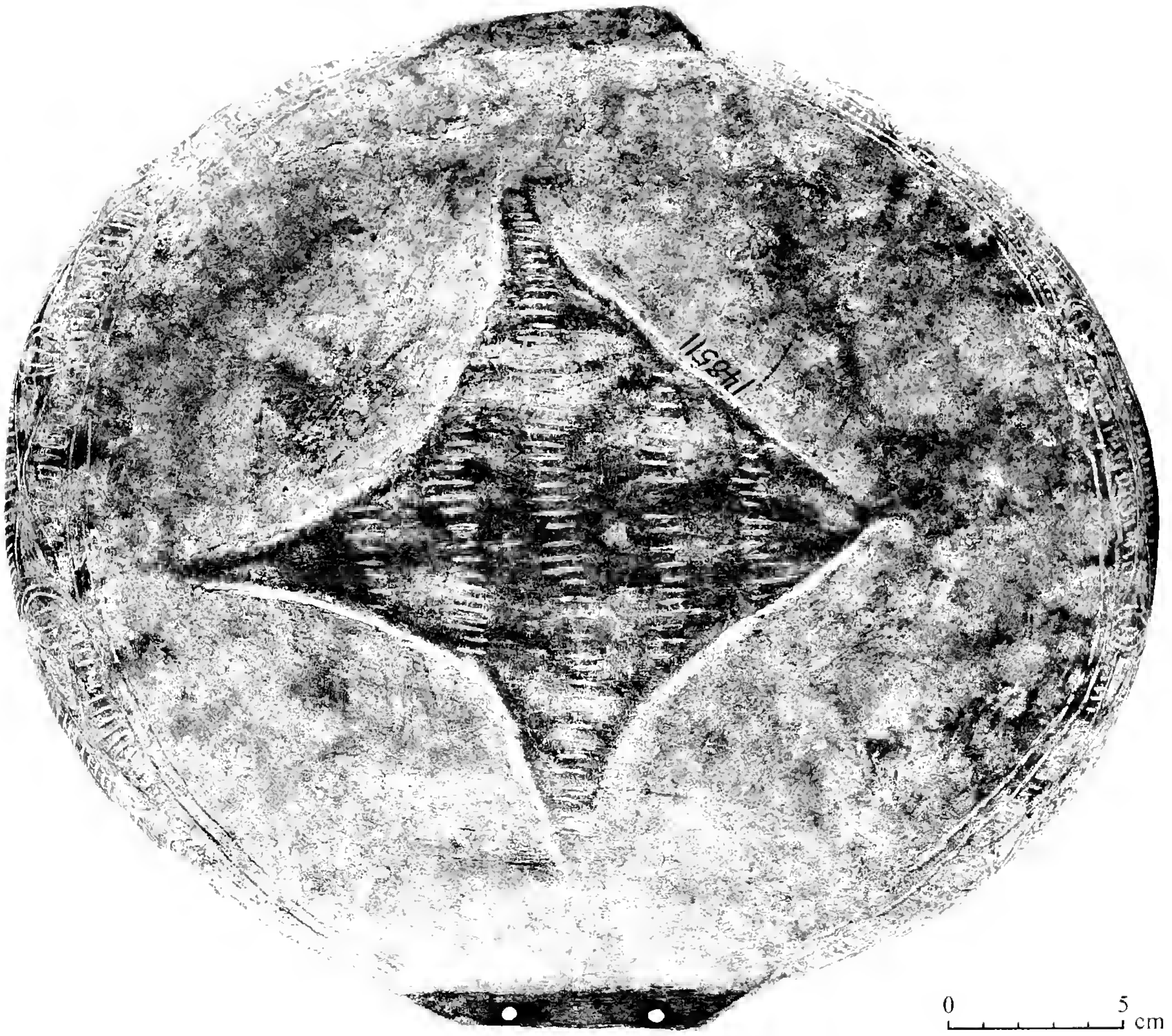

FIG. 9.15. Wooden bowl or platter with side lugs and border decoration from Walifu (Walis) Island (FMNH no. 148511, George A. Dorsey Collection, 1908; FMNH neg. no. A114431).

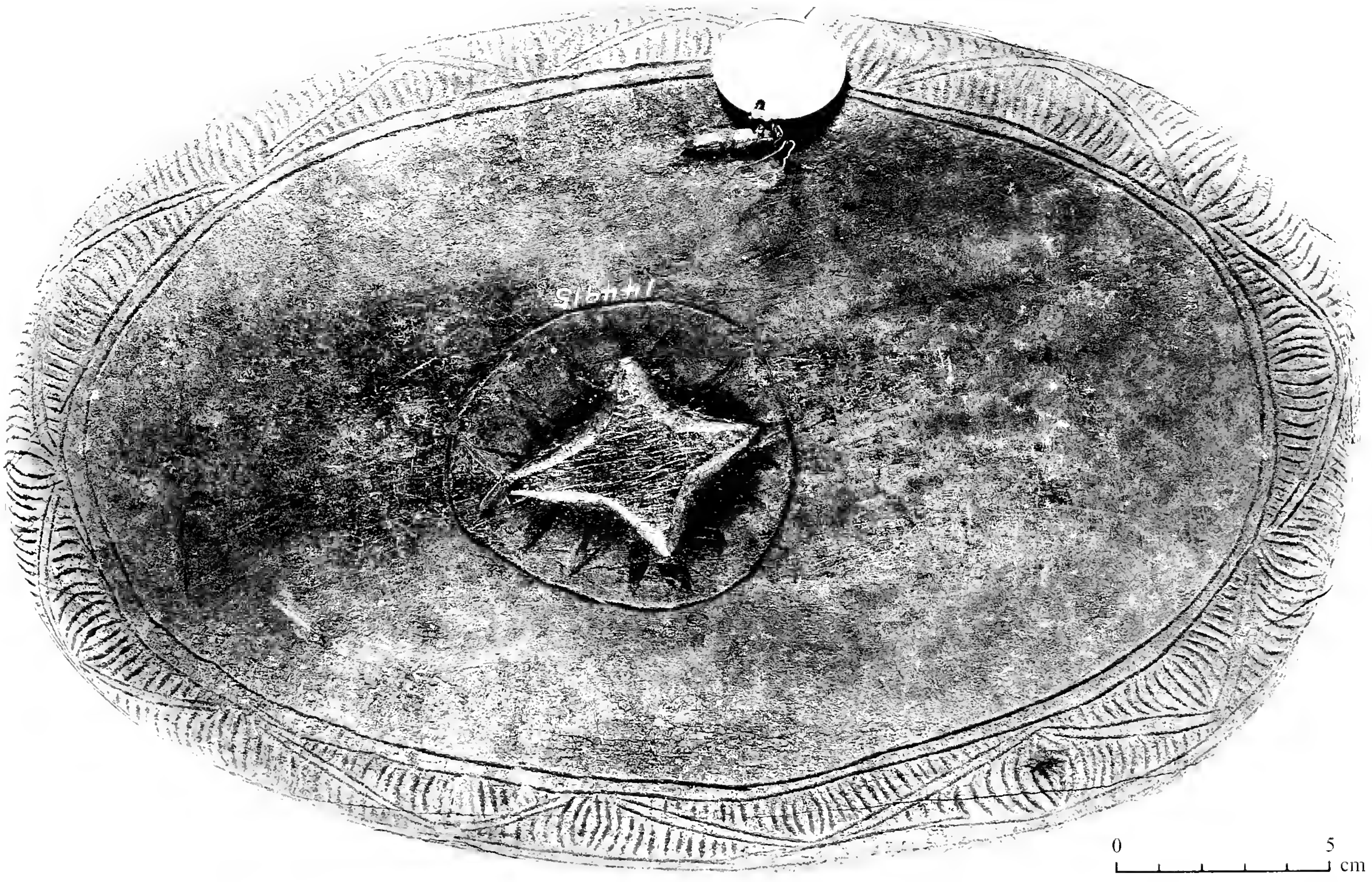

FIG. 9.16. Wooden platter from Seleo Island (FMNH no. 144915, Voogdt and others Collection, 1913; FMNH neg. no. A114369).

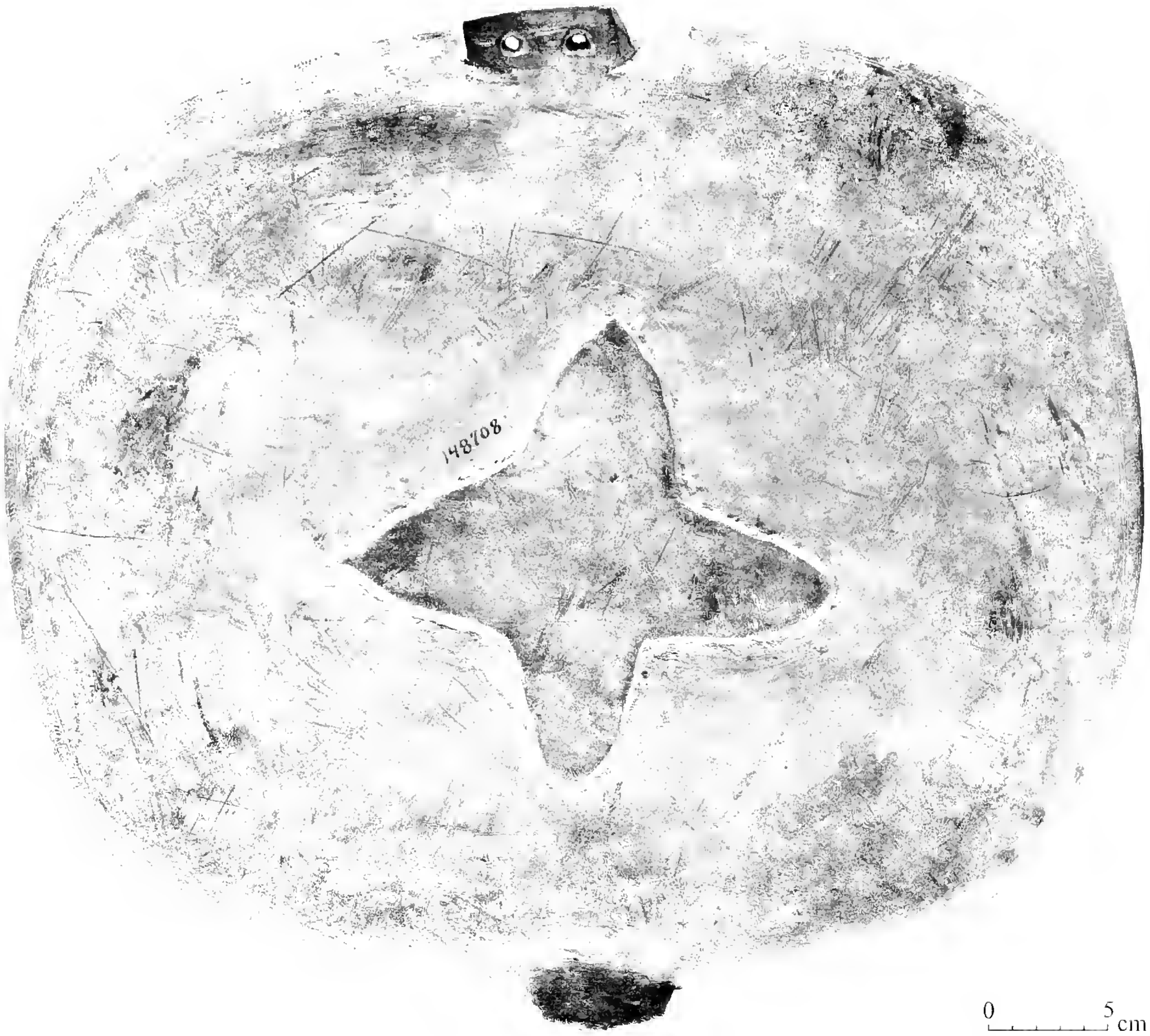

FIG. 9.17. Wooden platter from Smain (FMNH no. 148708, George A. Dorsey Collection, 1908; FMNH neg. no. A114433).

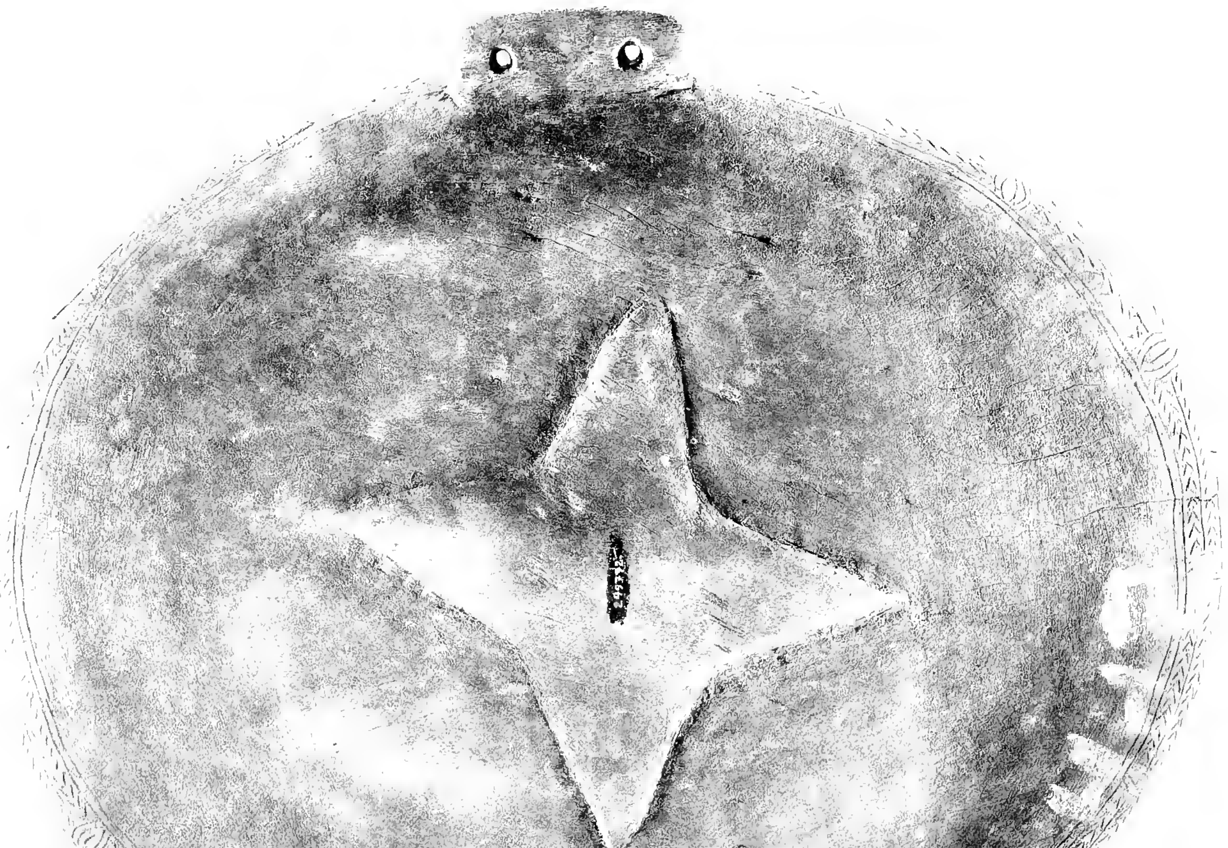

FIG. 9.18. Wooden bowl or platter from Angel Island; made by Mami, sold by his daughter Maria Rano; on bottom in center, a four-pointed star (*anang*), which is a clan design (FMNH no. 249772, Welsch, Oltomo, Terrell Collection 1993–1994; FMNH neg. no. A114378).

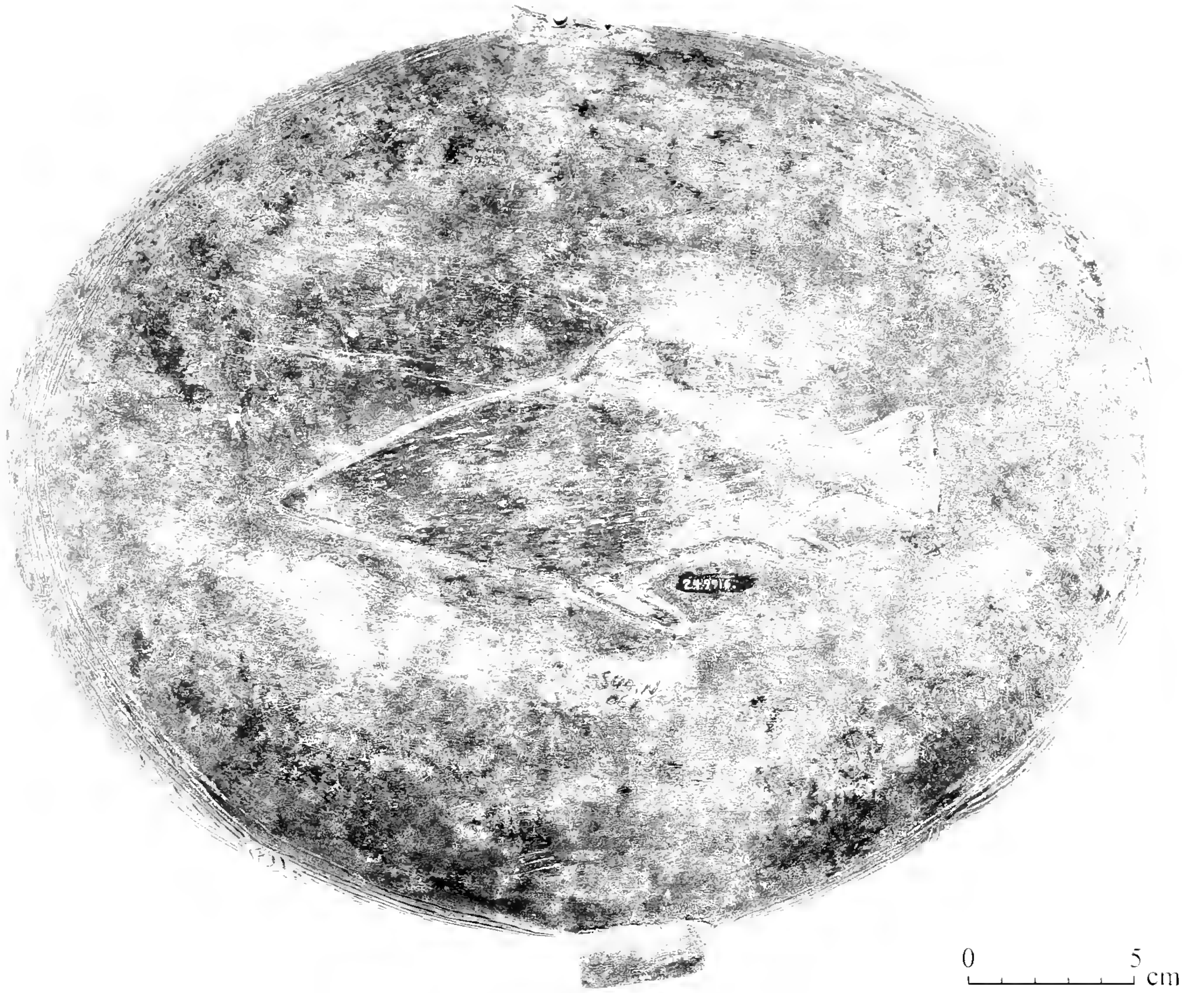

FIG. 9.19. Wooden platter from Suain; made by Demien Dan; this platter has a fish design called *rear* on it; the general term for design is *jerau* (FMNH no. 249916, Welsch, Oltomo, Terrell Collection 1993–1994; FMNH neg. no. A114379).

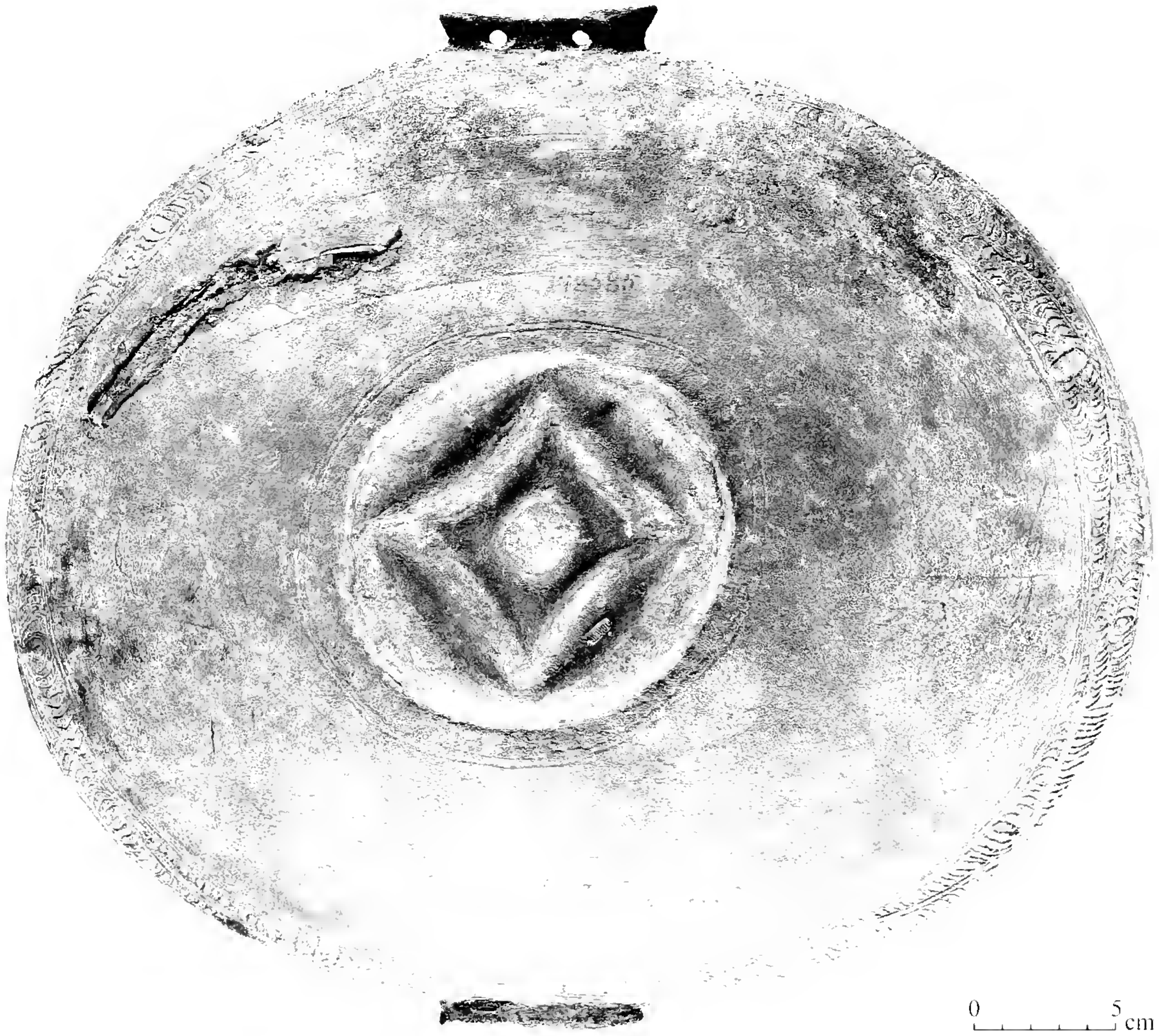

FIG. 9.20. Wooden bowl or platter from Tandanye (Tarawai) Island (FMNH no. 148585, George A. Dorsey Collection, 1908; FMNH neg. no. A114432).

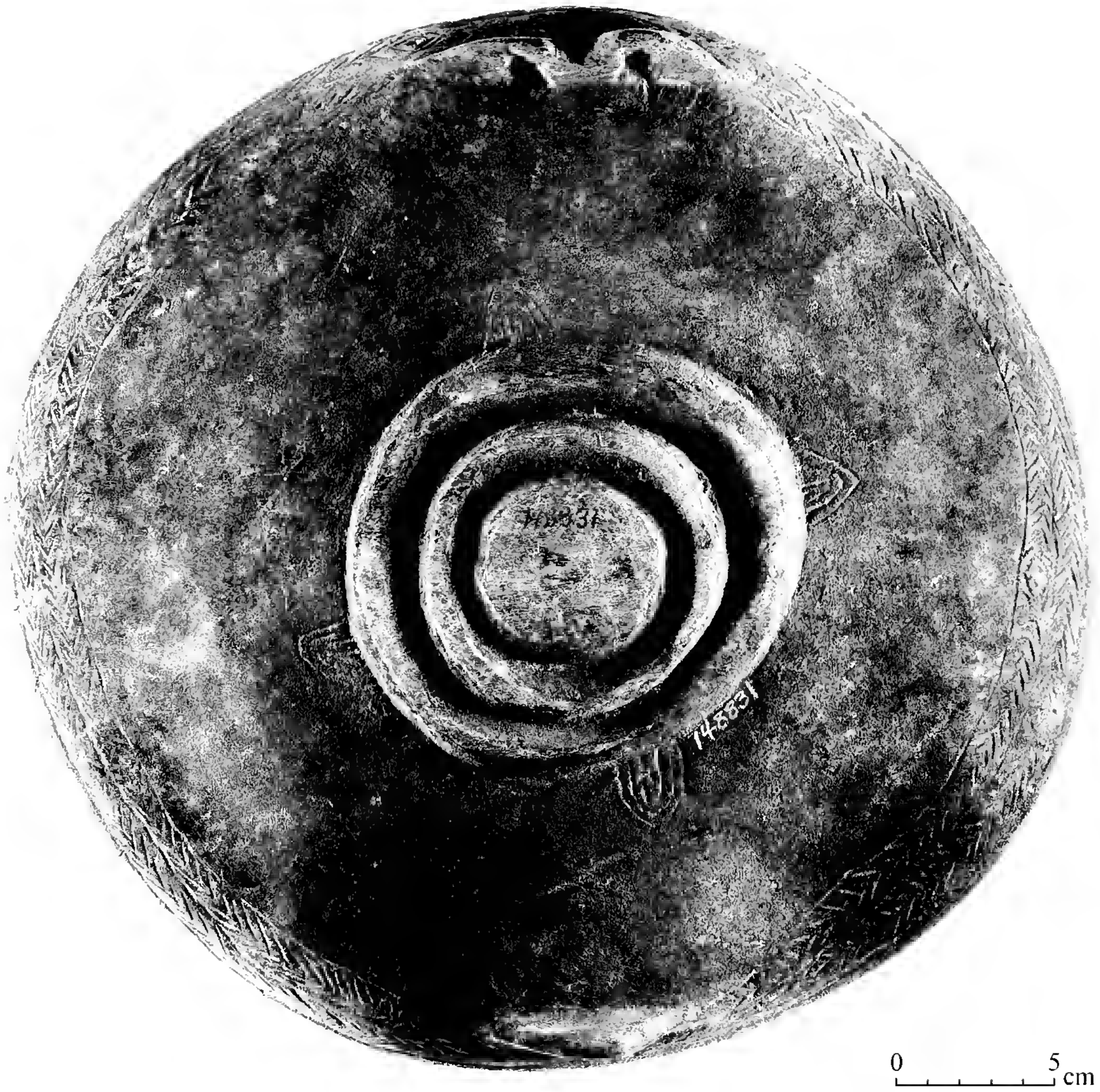

FIG. 9.21. Wooden bowl or platter from Seleo Island (FMNH no. 148831, George A. Dorsey Collection, 1908; FMNH neg. no. A114375).

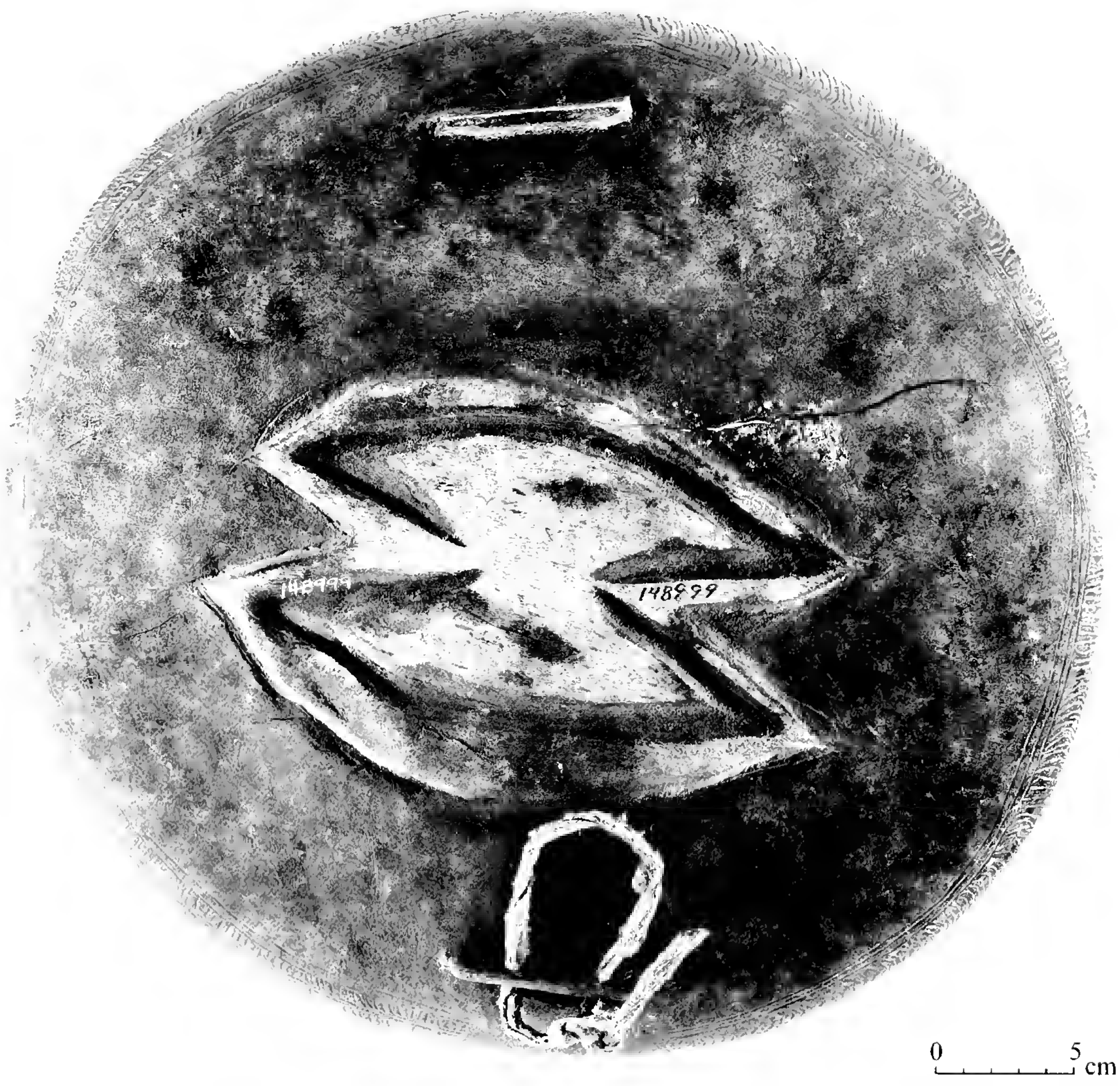

FIG. 9.22. Wooden bowl or platter from Angel Island (FMNH no. 148999, George A. Dorsey Collection, 1908; FMNH neg. no. A114377).

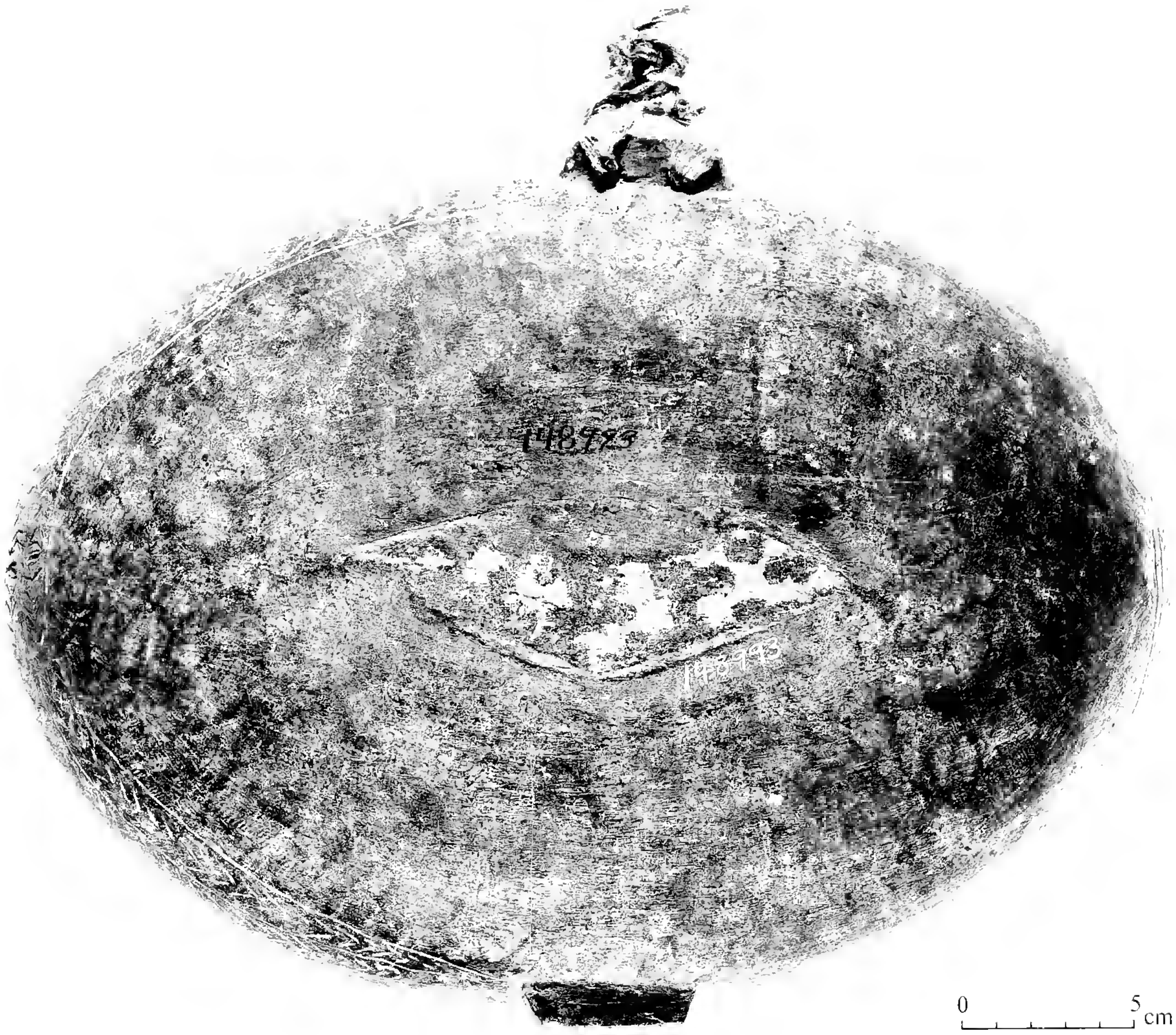

Fig. 9.23. Wooden bowl or platter from Angel Island (FMNH no. 148993, George A. Dorsey Collection, 1908; FMNH neg. no. A114376).

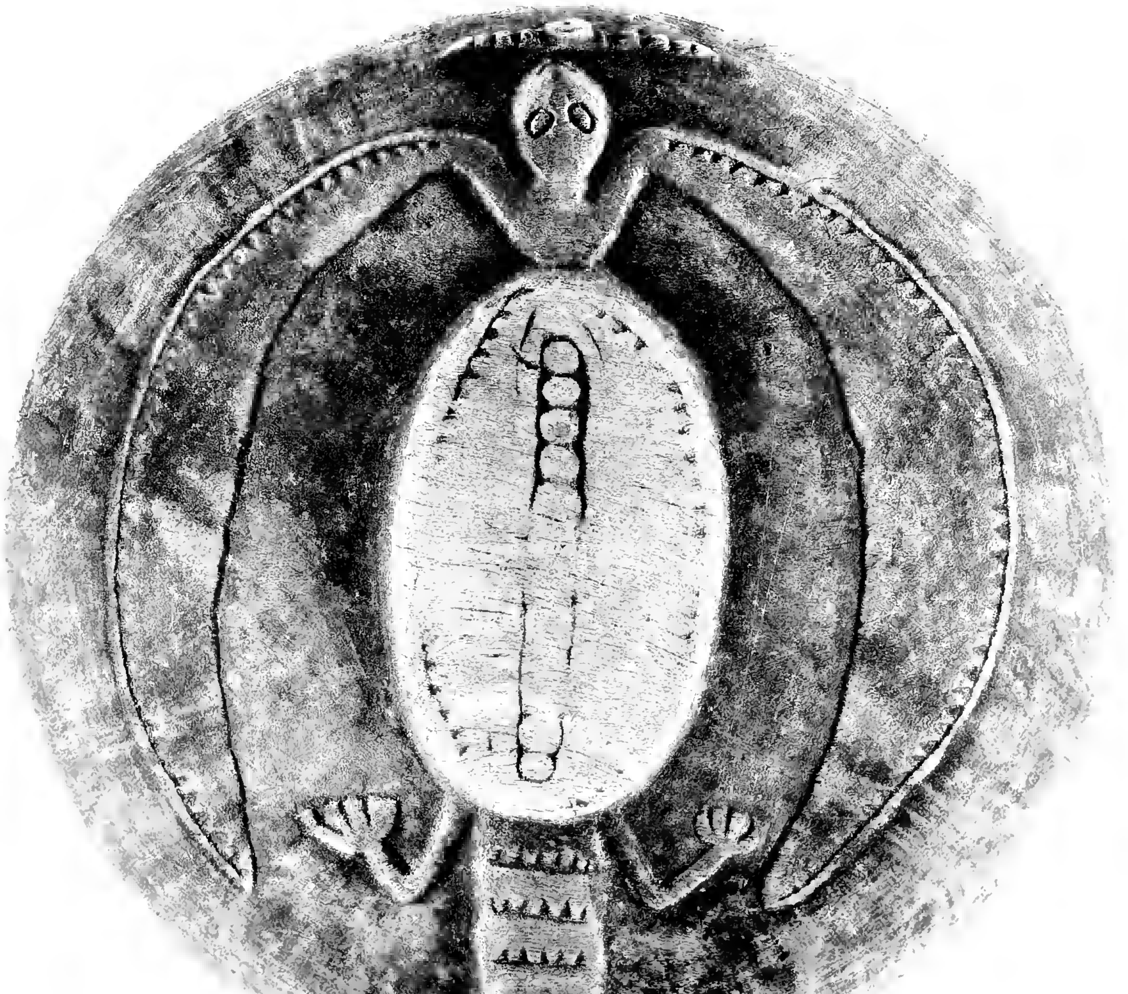

Fig. 9.24. Wooden bowl or platter from Kirau; probably made in interior Mom or Kayan (FMNH no. 140721, A. B. Lewis Collection, 1909–1913; FMNH neg. no. A114366).

FIG. 9.25. Wooden bowl or platter from Tandanye (Tarawai) Island (FMNH no. 148556, George A. Dorsey Collection, 1908; FMNH neg. no. A114374).

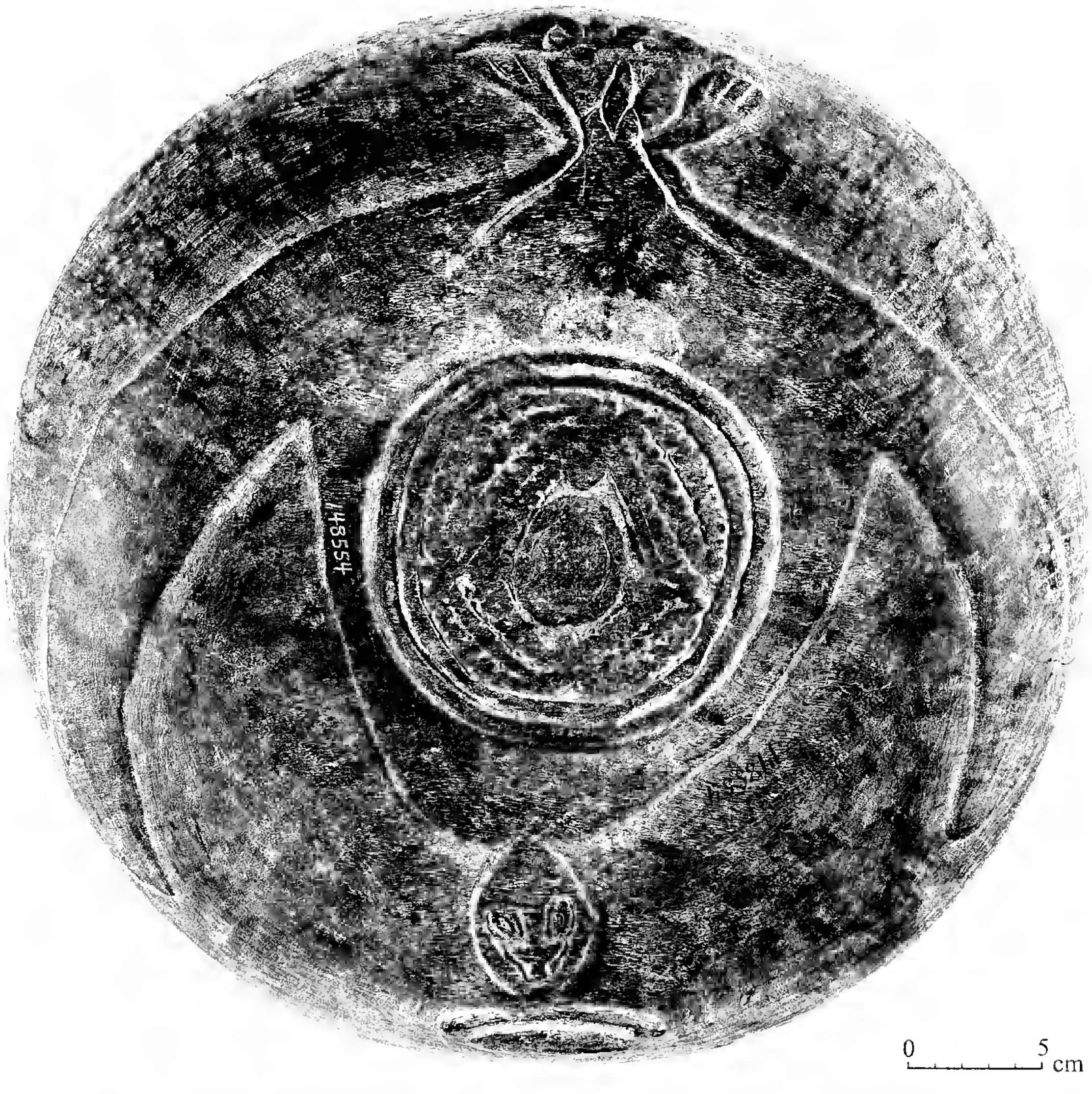

FIG. 9.26. Wooden bowl or platter from Tandanye (Tarawai) Island (FMNH no. 148554, George A. Dorsey Collection, 1908; FMNH neg. no. A114373).

FIG. 9.27. Wooden bowl or platter from Murik (FMNH no. 140940, A. B. Lewis Collection, 1909–1913; FMNH neg. no. A114368).

FIG. 9.28. Wooden bowl or platter from Murik (FMNH no. 140939, A. B. Lewis Collection, 1909–1913; FMNH neg. no. A114367).

FIG. 9.29. Wooden bowl or platter from Kep; made by Robert Karok, sold by his son Thomas Sareo; represents flying fox (*bunun*); central medallion said to represent a pillow (*kaluk*) (FMNH no. 250123, Welsch Collection, 1997; FMNH neg. no. A114536).

FIG. 9.30. Wooden bowl or platter from Kep; made by Abel Namir, sold by his wife Elizabeth Namir; represents flying fox (*bunun*) (FMNH no. 250133, Welsch Collection, 1997; FMNH neg. no. A114537).

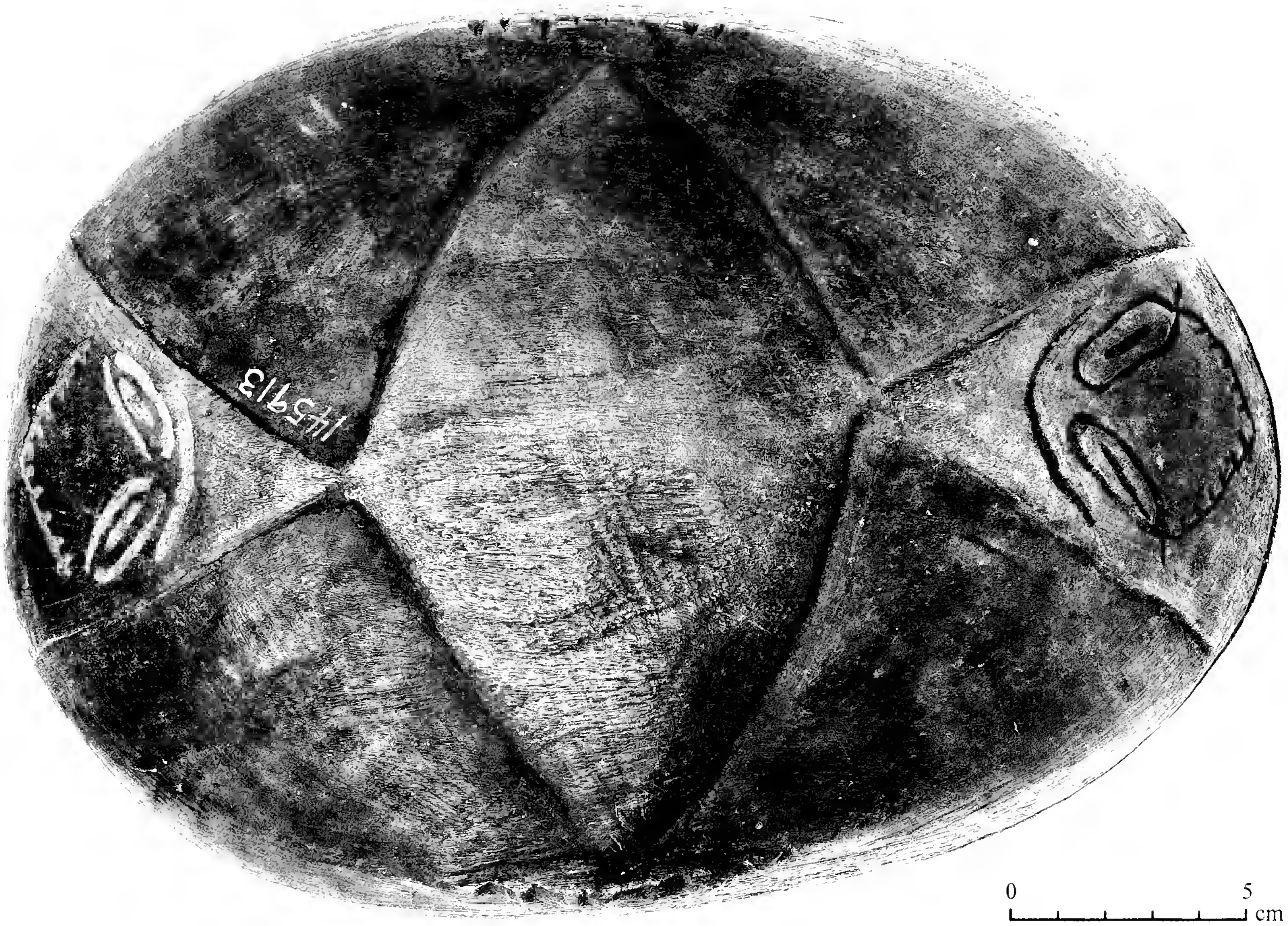

FIG. 9.31. Wooden bowl or platter from Walifu (Walis) Island (FMNH no. 145913, Voogdt and others Collection, 1913; FMNH neg. no. A114371).

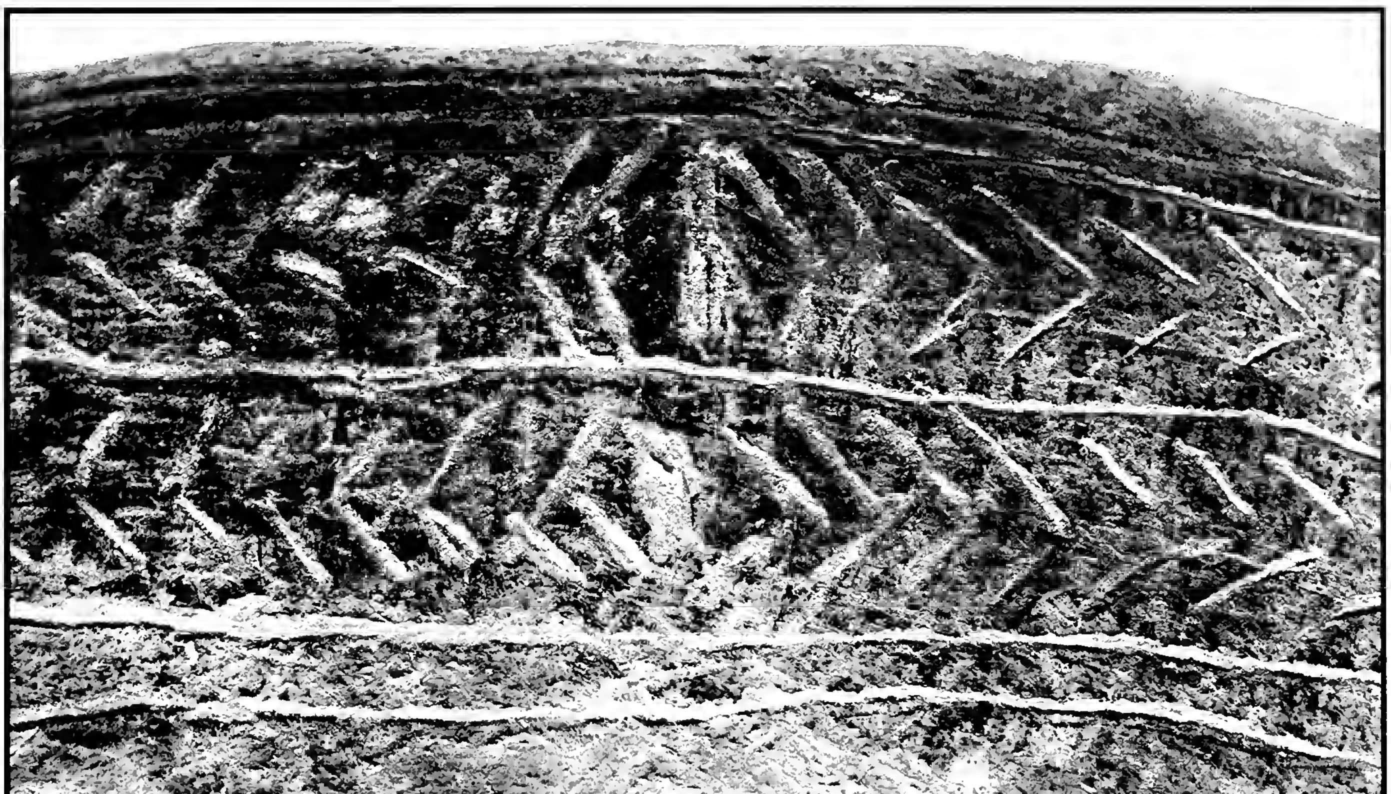

FIG. 9.32. Detail of the rim carving on a wooden bowl or platter from Angel Island (FMNH no. 148993, George A. Dorsey Collection, 1908; FMNH neg. no. A114376).

Fig. 9.33. Detail of the rim carving on a wooden bowl or platter from Tandanye (Tarawai) Island (FMNH no. 148585, George A. Dorsey Collection, 1908; FMNH neg. no. A114432).

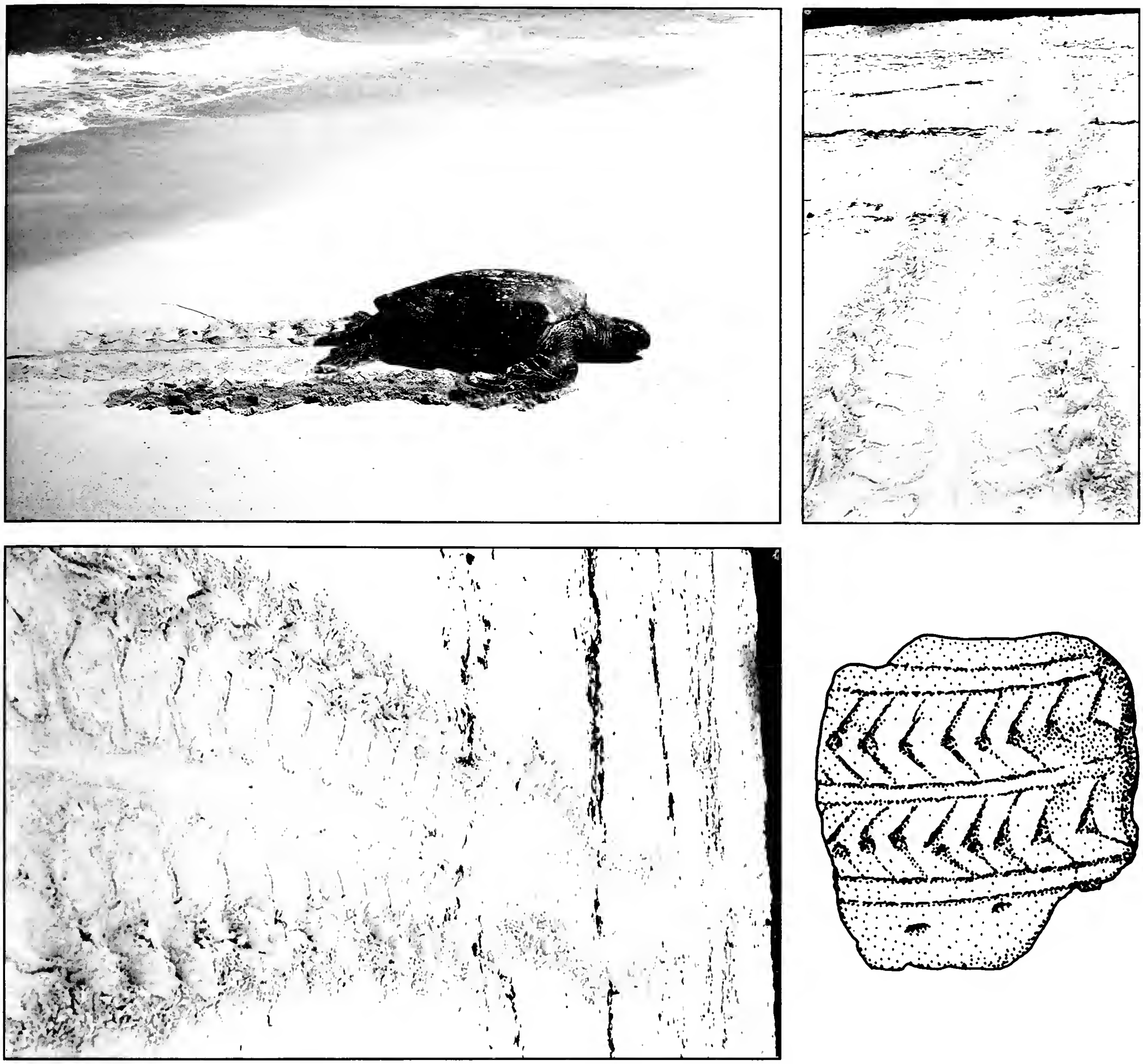

FIG. 9.34. **Top left**: Green sea turtle on her way to a nesting site (photograph courtesy of Regina Woodrom Luna); **top right**: track of a green sea turtle, *Chelonia mydas*, at Atol das Rocas; **bottom left**: track rotated to emphasize similarity with design motif occurring on Wain Ware and modern wooden bowls and platters made on the Sepik coast (similarity first noted by Regina Woodrom Luna). Photograph courtesy of Paula Baldassin; source: http://www.seaturtle.org; **bottom right**: Wain sherd.

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Chapter 10: Ancient Mortuary Ritual and Human Taphonomy

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Abstract

Human and nonhuman faunal remains from small deposits at three sites, NGRP 16, 23, and 46, were analyzed to determine the species and minimum numbers of individuals represented, and to investigate the processes of natural and human-induced modification that resulted in the extensive fragmentation of the human remains. Taphonomic analysis indicates perimortem modification of the human remains during disarticulation and processing as well as pig predation. The types and locations of tool marks, fractures, and fracture products are quantified and described, and quantitative taphonomic profiles for the human remains are compared to human and nonhuman bone assemblages from middens and normative burial contexts on Fiji. The NGRP assemblages do not taphonomically match other assemblages believed to represent incidents of cannibalism, but this does not rule out the consumption of human flesh or decomposition fluids. We reject the notion of a universal taphonomic signature of cannibalism, and find it more constructive to examine these data in the context of archaeologically and ethnographically documented mortuary practice in the region. We propose that the assemblages from these sites represent secondary deposits of human remains that were part of multistage mortuary programs that included the curation of specific skeletal elements, as documented in ethnographic accounts of mortuary ritual across Melanesia and far into antiquity. This study presented an interesting test of how we identify and interpret evidence of mortuary behavior when we encounter assemblages of human remains that do not fit the traditional concept of a burial or mortuary feature as most archaeologists know it.

Introduction

In this study, we report on human and nonhuman faunal remains from the archaeological excavations done in the Aitape area in 1996 (Chapter 6). The materials recovered at two of the localities examined (NGRP 16 and 23) come from what are thought to be single component cultural deposits dating to the late first millennium AD (Chapters 6 and 14). The rest of the material considered came from the three adjacent test excavations on Tumleo Island (NGRP 46) that were instrumental in defining a ceramic sequence for this part of New Guinea for the past 1,500–2,000 years (Chapter 7). No subsurface cultural features were observed in any of the deposits excavated, and it was apparent in the field that human bone was mixed with animal bone at two of these locations (NGRP 16 and 23), which led to the working hypothesis that the individuals represented might have been cannibalized. We undertook systematic taphonomic analyses to address this hypothesis during which we documented the anatomical and spatial distributions of the human and faunal remains to reconstruct their depositional history and recorded indications of cultural and natural modification. We then compared our findings with the results of similar studies recently done in the Fiji archipelago, and consulted the archaeological and ethnographic literatures on burial and mortuary behavior in New Guinea for comparative and contextual information.

In this regard, we found the Field Museum of Natural History's A. B. Lewis Collection as well as Lewis's field diaries (Welsch et al., 1992; Welsch, 1998) to be especially helpful (Chapter 4), particularly his descriptions of multistage mortuary programs that included secondary burial and selective element curation. Additionally, our taphonomic analyses of the Museum's holdings of historic crania collected by Lewis and others (Rieth, 2000; Stodder, 2006) have also documented parallels between what we have been able to reconstruct as prehistoric mortuary behavior at Aitape and how the skulls were treated and curated there at the turn of the last century, shortly after significant foreign contact. While we are not suggesting that mortuary procedures were exactly the same at Aitape in AD 700 as they were in 1900, the parallels suggest that we should seek an explanation other than cannibalism for the presence of fragmentary human bone in the Aitape archaeological deposits.

Based on these analyses, we propose that the human remains from NGRP 16, 23, and 46 represent the secondary burials likely associated with the curation of specific skeletal elements. Although the Aitape human remains exhibit some of the taphonomic characteristics of cannibalism, as previously reported (Stodder et al., 2001; Stodder & Rieth, 2003; Stodder, 2005), these assemblages do not fit all the commonly used criteria for validating claims of cannibalism in the archaeological record. We believe that it is significant that these assemblages instead exhibit similarities with known patterns of

TABLE 10.1. Vertebrate faunal components in New Guinea Research Program (NGRP sites), 1996.

Type	NGRP 23		NGRP 16		NGRP 46	
	n	%	*n*	%	*n*	%
Human	1,159	34	530	95	8	6
Pig	1,060	31	8	2	56	42
Pig/human	843	25	1	0	11	8
Dog	25	<1	0	0	5	4
Fish	3	<1	5	1	13	10
Turtle	0	0	0	0	8	6
Bird	0	0	0	0	1	1
Rodent	8	<1	6	1	4	3
Indeterminate	264	8	5	1	26	20
Other	4	<1				
Total NISP[a]	**3,366**		**555**		**132**	

[a] NISP = number of individual specimens; pig/human: pig or human.

mortuary behavior in New Guinea attested both archaeologically and ethnographically. Combining taphonomic analysis with contextual research on mortuary patterns in New Guinea leads to a more comprehensive understanding of the human and natural processes responsible for the condition and distribution of the human remains excavated in 1996.

Faunal Remains

In this section, we describe the nonhuman and human bone assemblages from the three sites, including the spatial and anatomical distribution of bone and the numbers of individuals represented.

Bone from NGRP 16

NGRP 16 is located on the top of a small knoll 200 m above sea level, 2 km from the coast. A 3 × 3-m area excavation of 1-m squares and two small shovel probes were excavated (Chapter 6). Four layers (A–D) were identified in the stratigraphic profile, all containing numerous pebbles, cobbles, and blocks of limestone. The archaeological interpretation of this site is that it is the result of a single, relatively brief period of cultural deposition, and that the deposit is a stone and refuse dump where loose pieces of limestone, pottery, bone, and shells from elsewhere had been discarded, perhaps as a result of ground clearance for a living area or house complex of some sort located nearby on the ridge top. It is difficult to reconcile this interpretation of Site 16's formation and function with the presence of human remains.

Material recovered includes 555 bone fragments. Ninety-five percent (530 of 555) of the bone in the assemblage is identifiable as human, representing a minimum number of individuals (MNI) of three (Table 10.1). The remaining 5% includes five fish bones, six fragments of rodent bone, eight pig teeth, and two other tooth fragments identifiable as "possibly pig," and 11 element fragments that are unidentified or only tentatively identified (the identifiability of most of the bone fragments is limited by their small size). The nonhuman remains range in size from 0.7 to 1.5 cm. Average size of human bone fragments is 2.14 cm, and the largest fragment of human bone is 11 cm.

SPATIAL DISTRIBUTION OF BONE—Two distinct concentrations of human bone were present. The 446 bone fragments from these concentrations account for 87% of the human remains from the site, and represent the incomplete remains of two adults, individuals 16-1 and 16-2. The MNI for adults is based on two incomplete but partially reconstructable left femora and two left tibiae. Individual 16-1 is an adult female, estimated to have been between 33 and 38 years at death, based on morphology of the innominate and the auricular surface of the ilium (Lovejoy et al., 1985). The sex of Individual 16-2 is not known, and age can be assessed only as older than about 16 years, based on the erupted third molar.

A subadult, Individual 16-3, is represented by a deciduous incisor and 15 cranial and axial fragments. These remains were more spatially dispersed than the adult fragments. Age at death of this individual is estimated as two to three years.

The human bone was concentrated in the northern row of 1-m excavation squares, but the shell was more broadly distributed across all nine squares of the 3 × 3-m areal excavation, with somewhat of a northeast–southwest trend to the concentration in squares A-1, B-2, and C-3. The vertical distribution of bone and shell does not seem to indicate that the bone was deposited primarily on top of or beneath distinctive shell lenses.

ANATOMICAL DISTRIBUTION OF BONE—The anatomical distribution of the human bone fragments is indicated in Table 10.2. Ten percent of the fragments are from the cranium. Leg and foot bone fragments make up 79%, and arm and hand bones 3% of the assemblage. In part, this pattern results from the fact that there are larger and more durable bones in the legs and feet, which can create more fragments if fractured; however, selective deposition is suggested as well.

While the assemblage is anatomically diverse, some skeletal elements are not represented at all: facial bones (except for one maxilla fragment and three mandible fragments), the scapulae, lumbar vertebrae, and sacrum. The cranial remains are predominantly parietal, temporal, and frontal fragments. Axial remains include a possible clavicle fragment, one or two rib fragments, four vertebra fragments, and an innominate fragment. The only arm bones identified are one ulna fragment and three fragments of humerus or radius. Hand bones include eight phalanges and three metacarpals. In contrast, there are nearly 400 fragments from leg bones as well as patella fragments. Foot bones are considerably more abundant than hand bones, with the talus, calcaneus, navicular, and second cuneiform represented, in addition to metatarsals and phalanges. With the exception of a tiny ear

Table 10.2. Anatomical distribution of human bone, NGRP 16.

Segment	n	%
Cranial and dental	**55**	10
Cranial	46	9
Dental	9	
Axial	**12**	2
Upper limb	**15**	3
Arm	4	
Hand	11	
Lower limb	**424**	79
Leg	350	
Leg/foot	48	
Foot	26	
Postcranial	(483)	90
Hand/foot	**11**	
Indeterminate postcranial	21	
Total NISP[a]	**538**	

[a] NISP = number of individual specimens.

bone, there is not a single complete skeletal element in the NGRP 16 assemblage.

Bone from NGRP 46

Three test pits were excavated on Tumleo Island, NGRP 46: test pit 1 (squares A–C), test pit 2, and test pit 3 (Chapter 6). Up to six discernible layers were identified in stratigraphic profile. The 132 bone fragments from NGRP 46 represent an array of fauna including pig, fish, turtle, dog, rodent, bird, and human (Table 10.1). Pig bone is the most abundant, making up 42% of the assemblage. Fish bone is the second most frequent, representing 10% of the remains. Fragments of either pig or human bone account for 8%. Turtle and human bones each make up 6% of the assemblage. In addition, five dog teeth (4%), four rodent bones (3%), and one bird bone (1%) were found. Eight bone fragments could be definitely identified as human (6%), representing an MNI of one.

Spatial Distribution of Bone—Pig bone was found in eight excavation units (test pit/layer), and was more widely distributed than human bone, which was found in only five units. Unlike NGRP 16, there is not a distinct concentration of human bone within the NGRP 46 deposits.

Anatomical Distribution of Nonhuman Bone—The pig bone from NGRP 46 is from at least two individuals: a subadult and at least one adult. The subadult is represented by two teeth and a long bone fragment, while the adult is represented by teeth, five cranial and maxilla fragments, and 13 axial fragments, including portions of scapula, vertebrae, ribs, and pelvis. In clear contrast to the pig bone from the two mainland coastal sites, remains of limbs and feet/trotters make up 71% of the assemblage from NGRP 46. The dog remains consist of teeth only, none of which appears to have been worked. The fish remains include three vertebrae from a shark or ray and two vertebrae from small fish. The fish, pig, and turtle remains clearly suggest food debris, and support the hypothesis that these deposits represent domestic midden.

Anatomical Distribution of Human Bone—The human bone assemblage represents a minimum of one adult, but no further assessment of age or sex is possible from the fragments. No cranial remains were found, but there is a fragment of the crown of a mandibular right molar. No bone fragments from the axial skeleton were found. An ulna shaft tube fragment and a fragment of a proximal hand phalanx represent the upper limb. A conjoined set of fragments from either a femur or a tibia shaft, a shaft splinter from the distal portion of a first metatarsal, and the medial half of a right navicular are present from the lower limb.

Bone from NGRP 23

NGRP 23 is located on the hilltop west of NGRP 16 (Chapter 6). The excavation of four 1 × 2-m and one 1 × 1-m units yielded an assemblage of shell, Sumalo Ware sherds, ground stone artifacts, small amounts of flaked stone tools and obsidian debitage, more than 1,000 small pieces of human bone, and more than 2,000 fragments of animal bone. The deposit filled a small, irregular natural limestone crevice on the hilltop. Four strata (levels A–D) were observed, with substrata C-1 and C-2 present in part of the area.

The faunal assemblage from NGRP 23 comprises 3,366 fragments, and is predominantly pig and human, with few other species represented (Table 10.1). The assemblage is 34% human bone and 31% pig bone. An additional 25% of the bone was identifiable only as pig or human, so the assemblage is 90% pig and human. The pig remains produce an MNI of 11, and the human remains represent an MNI of seven. Of the remaining 10%, 8% were unidentifiable. The small nonhuman and nonpig assemblage includes 25 dog teeth (<1%), three fish vertebrae (<1%), eight rodent bones (<1%), and four bone fragments identifiable as mammal only (<1%). No bird or turtle remains were found at NGRP 23.

Spatial Distribution of Bone—The pig and human bone are not evenly co-distributed across the site. The horizontal units with the most pig bone have the least human bone and vice versa. A significant portion of the shell overlies the human bone, as do many of the pig mandibles (Fig. 10.1). One individual, 23-6, is concentrated in the westernmost unit, square 2E, and the remains of this young adult male individual are better preserved than the other bone. The remains of the other adults are spread over four test units, 2A–2D. Within these, bone fragments from the upper body are clustered in 2A and 2D, while fragments from the lower body are in 2B and 2C. There are two instances of deliberate placement of piles, or stacks, of four or five reconstructable long bones, indicating that these were deposited as intact long bones but not as parts of intact bodies.

Anatomical Distribution of the Pig Bone—Anatomically, the human bone and pig bone assemblages from NGRP 23 are strikingly different (Table 10.3). The human assemblage is comprised of 22% cranial and 78% postcranial bone. The pig assemblage is 96% cranial and 4% postcranial bone, much of which is accounted for by a set of caudal vertebrae. In fact, the pig bone assemblage consists overwhelmingly of mandible fragments and teeth. The 445 mandible fragments represent a minimum of nine individuals; 275 teeth represent an MNI of 11. In addition, there are 41 maxilla fragments, 77 maxilla or mandible fragments, and 133 other cranial fragments, mostly unidentifiable. The near total absence of elements from the consumable, fleshy portions of the pig diverges from what we expect in a kitchen midden filled with food remains, and indicates selective discard of pig remains. This abundance of

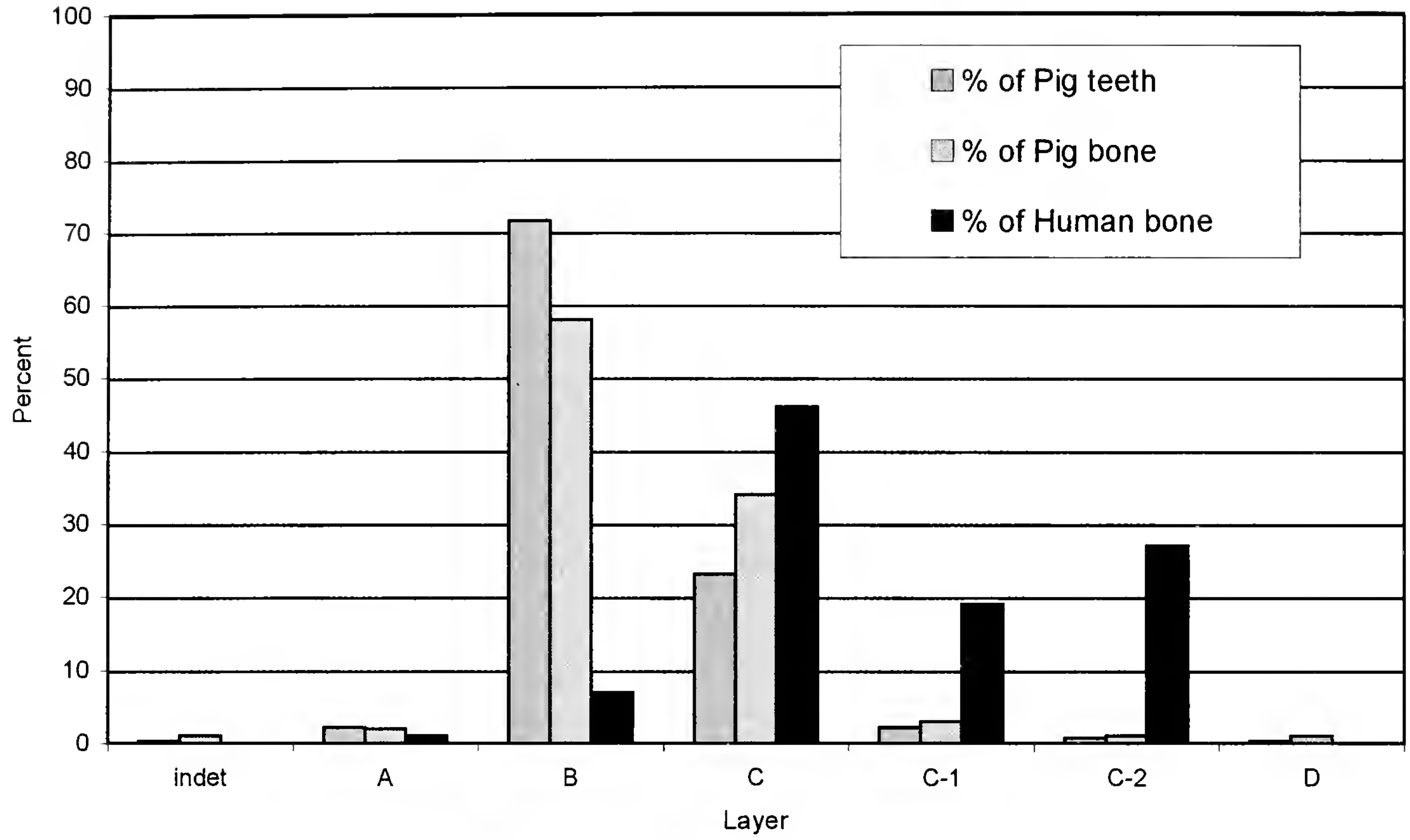

FIG. 10.1. Vertical distributions of pig teeth, pig bone, and human bone, NGRP 23.

mandibles is suggestive of the practice in many parts of New Guinea and Southeast Asia of keeping pig mandibles in trophy arrays in men's ceremonial houses (Gorecki & Pernetta, 1989; Hyndman, 1991; Griffin, 1998). The killing and/or trading of pigs is an integral part of mortuary programs as described in Papua New Guinea and other parts of Melanesia (Jolly, 1984; Macintyre, 1984; Goodale, 1985; Foster, 1990). The concentration of pig mandibles and human bones suggests a ritual component to the NGRP 23 deposit.

ANATOMICAL DISTRIBUTION OF HUMAN BONE—The human bone is widely distributed anatomically, but several parts of the skeleton are minimally represented: facial bones and the coronal portion of the skull, the radius, ulna, carpals, clavicles, lumbar and sacral vertebrae, and the femur. The minimum number of each skeletal element represented in the human assemblage ranges from one to six (tibiae), and the MNIs derived from the elements range from one to four (Table 10.4). The cranial fragments are from at least two adults and one subadult. Subadults are represented by a few teeth, mandible fragments, a petrous portion, and two long bone fragments.

The entire assemblage of human remains represents a minimum of seven individuals: four adults (two males, one female, and one individual of unknown sex) and three subadults. While the MNI data indicate the number of individuals represented, only a few bone fragments could be confidently assigned to a specific individual (Table 10.5). The majority cannot be assigned on the basis of either proximity or morphological features; four adults are represented by tibiae, but we do not know which tibiae (if any) came from the same individuals as the skull fragments or the reconstructed mandible (Figs. 6.10 and 10.2).

Individual 23-6, an adult male recovered from square 2E, is markedly more complete and spatially distinct than any other individuals represented in the NGRP assemblages. The contrast between these remains and the more dispersed and incomplete remains of the other individuals represented by bone from the other four test squares at NGRP 23 suggest a different mode of deposition or perhaps a different depositional event. Perhaps he was interred as a more complete individual to begin with and the others were moved from a different context and placed here after his death. Taphonomic data from the bone from Individual 23-6 and bone from the other test pits are used to address these questions below.

TABLE 10.3. Anatomical distribution of pig and human bone, NGRP 23.

Segment	Human *n*	Human %	Pig *n*	Pig %
Cranial and dental	**230**	22	**971**	96
Cranial	151	14	696	69
Dental	79	7	275	27
Axial	**201**	19	**22**	2
Postcranial	(830)	78	(40)	4
Upper limb	**68**	6		
Lower limb	**292**	28	**5**[a]	<1
Hand/foot	**115**	11	**3**	<1
Indeterminate postcranial	**154**	15	**8**	<1
Total NISP[b]	**1,060**		**1,011**	

[a] Upper and lower limb combined for pig bone.
[b] NISP = number of individual specimens.

Summary

The faunal assemblages from the three sites exhibit some clear differences (Table 10.1). NGRP 23 has generally equivalent proportions of human (34%) and pig (31%) bone, and an almost equally large proportion (25%) of bone that is either pig or human. The assemblage from NGRP 16, on the adjacent hilltop, is 95% human. The small assemblage from

TABLE 10.4. NISP, MNE, and MNI represented in identifiable human bone, NGRP 23.[a]

Element	NISP	MNE	MNI
Occipital	11	1	1A
Frontal	9	2	1A, 1SA
Malar	1	1	1A
Mandible	47	2	1A, 1SA
Maxilla	6	1	1A
Parietal	16	2	1A, 1SA
Temporal	29	3	2A, 1SA
Zygomatic	3	2	1A, 1SA?
Dentition	79		3A, 2SA
Clavicle	2	1	1A
Scapula	7	2	2A
Rib	83	?	1A
Vertebra, cervical	6	3	2A
Vertebra, thoracic	67	7	2A
Vertebra, lumbar	2	1	1A
Sacrum	2	1	1A
Innominate	22	2	2A
Humerus	51	4 (2R, 2L)	2A
Radius	3	2 (1L, S?)	2A
Ulna	8	2 (1R, 1L)	1A
Hand phalanges, proximal	7	1	1A
Hand phalanges, medial	11	11?	2A?
Hand phalanges, distal	2	2	1A
Femur	41	2 (1R, 1L)	1A
Tibia	205	6 (2R, 4L)	4A
Fibula	39	4 (2R, 2L)	2A
Patella	6	1 (1L)	1A
Talus	3	2 (2L)	2A
Calcaneus	12	2 (1R, 1L)	1A
Navicular	3	3 (1R, 2L)	2A
Foot phalanges, proximal	5	5?	1A
Foot phalanges, medial	6	6	1A

[a] NISP = number of individual specimens; MNE = minimum number of elements; MNI = minimum number of individuals represented; A = adult, SA = subadult, L = left, R = right, S? = side unknown.

NGRP 46 on Tumleo Island has the largest proportion of pig bone (42%), and a minimal amount of human bone (6%). The range of species is broadest in the island deposit, with fish, bird, and turtle represented. Except for three fish vertebrae, there are no nonpig food species represented in the NGRP 23 bone. The dog teeth present at this site, which were drilled for stringing, are interpreted as remains of belts or necklaces. These differences may be due in part to sampling bias and the limits of our analytical ability, but the data do raise questions about site function and what processes were active in creating such fragmented and distinctive assemblages of bone. A systematic taphonomic analysis focused on identifying and categorizing tool marks, thermal alteration, fracturing, animal chewing, and other abrasion patterns was conducted to begin answering these questions.

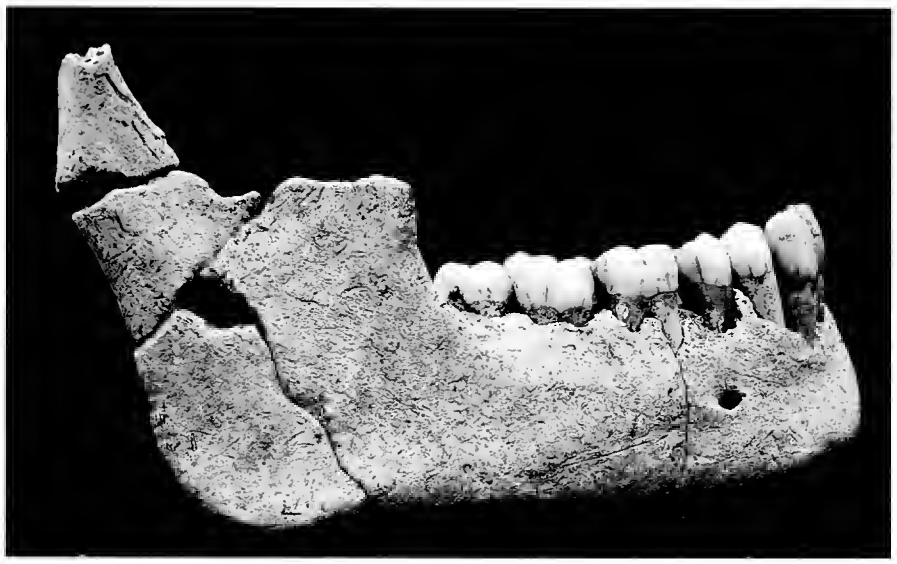

FIG. 10.2. Site 23 mandible reconstructed.

Taphonomy

Taphonomic data were collected in accordance with White's (1992) protocol with some modifications. The data for each site are summarized in Table 10.6 (NGRP 16), Table 10.7 (NGRP 46), and Table 10.8 (NGRP 23). The observations are grouped into categories: preservation, animal-induced damage, tool marks, postcranial fracture, and fracture products. Details on the locations of tool marks on human bone are listed in Table 10.9, and tool marks on nonhuman bone are listed in Table 10.10.

A major challenge with these assemblages has been to distinguish between animal- and human-induced modification of the bones. We believe that a great deal of the damage to the bone is the result of pig predation with considerable evidence of chewing, and it is clear that in some cases this resulted in breakage of the bone in the perimortem (or "green") state. Typical fragments with chewing marks, wear, and weathering are shown in Figure 10.3.

TABLE 10.5. Summary table for individuals, NGRP 23.

Individual	Unit[a]	Age, sex, criteria	Elements/fragments assignable
23-1	2A/C-1	adult, sex unknown	cranial fragments, first cervical vertebra
23-2	2A/C-1 2B/C-2	adult, female(?), gracile fibula	cranial fragments, first and second cervical vertebra
23-3	2B/B	adult, male, very robust fibula	fibula
23-4	2A/C	1–2-year-old: dental development	R zygomatic, 3 teeth, 1 toe phalanx
23-5	2E/C 2E/B 2D/B	4–6-year-old: dental development	19 mandible fragments, 2 teeth, 3 possible humerus fragments, 1 tibia fragment
23-6	2E/C 2D/C-2 2E/B 2E/D	adult, male: innominate, age: possibly under 19—maxillary third-molar roots initial development only	49 cranial and dental, 45 vertebral, 13 rib, 7 scapula, 13 innominate/sacrum, 37 arm, 4 hand, 108 leg, 45 foot bone fragments
23-7	2E/C	6 months in utero—length of petrous portion	petrous portion of temporal

[a] Unit = excavation unit (i.e., test pit/layer).

TABLE 10.6. Summary taphonomy data, human remains from NGRP 16.

Category	nw/nobs[a]	% w
Preservation		
Weathering scores	nobs = 204 mean = 1.35 SD = 1.08	
Rolling	179/204	88
Polish	2/201	1
Beveled fracture edges	1/34	3
Thermal alteration	1/209	<1
Animal damage		
Chew marks: any	127/209	61
Chewing	121/204	59
Ovoid pits	34/205	17
Rodent gnaw	3/207	1
Tooth puncture	17/208	8
Trampling/striae	76/205	37
Tool marks		
Tool marks: any	12/207	6
Chop marks	2/205	1
Scrape marks	4/208	2
Cut marks	4/206	2
U-shaped groove	4/156	3
Postcranial fracture		
Perimortem fracture	135/339	40
Postmortem fracture	204/339	60
Fracture products		
Crushing	9/183	5
Peeling	26/172	15
Incipient fracture crack	1/10	10
Percussion pits	1/205	<1
Associated percussion striae	1/1	100

[a] nw = number of fragments with modification; nobs = number of fragments observable.

NGRP 16 Taphonomy

PRESERVATION—The average size of the human bone fragments from NGRP 16 is 2.14 cm. The nonhuman bone fragments (two rodent bones, two fish bones, one pig or human fragment, and three unidentified bones) are smaller, averaging 1.2 cm. Weathering was scored using the 0–5 score system in Behrensmeyer (1978). Unweathered bone is scored as zero: stage 1—some cracking of the bone; stage 2—flaking of the outer layers of the bone; stage 3—erosion of the surface bone to a coarse fibrous texture; stage 4—deep cracks in the bone and increasingly coarse texture; and stage 5—more extensive cracking and splitting of the bone. Weathering scores for the NGRP 16 assemblage are low (Table 10.6). Almost 20% of the fragments are unweathered, and only about 11% were weathered at stage 3 or higher. Bone from Individual 16-1 is more weathered than bone from Individual 16-2: the average score for Individual 16-1 is 1.46 (n = 95, SD = 1.31), compared to 1.21 from Individual 16-2 (n = 92, SD = 0.75). This supports the interpretation that the two bone clusters are discrete depositional entities. Random striae are present on 37% of the fragments, and rolling damage is evident on 88%. Only one bone fragment exhibits thermal alteration.

ANIMAL DAMAGE—Damage from animal chewing is evident on 61% of the human bone. Rodent gnawing is rare, but 59% show larger parallel chew marks, often in association with ovoid pits, which we have identified as pig premolar and molar cusp marks and fracture edges. A total of 73 ovoid pits are present on 34 (17%) of the fragments. On 20 fragments, pits occur singly, but others have as many as seven pits. The pits range in size from 1.7 to 14.68 mm in diameter. This range suggests tooth size variation in pigs but may also indicate chewing by other species. Tooth pit size also varies with the density of the bone being chewed; cancellous bone near the metaphyses is less resistant than cortical bone in the diaphyses and midshafts, and larger tooth pits result (Selvaggio & Wilder, 2001). Tooth puncture marks, which could have been made by dogs or pigs, are present on 8% of the fragments, all from Individual 16-1.

TOOL MARKS—Tool marks are present on 6% of the fragments in the NGRP 16 human bone assemblage (listed in Table 10.6). Chop marks are present on 1% of the observable fragments. Scrape marks or cut marks are on 2%, and 3% have one or more U-shaped grooves. No tool marks were observed on bone assignable to Individual 16-2. The cut marks occur on a shaft splinter from a humerus or radius, on a splinter of the left fibula, and on finger phalanges.

With a couple of exceptions, the cut marks on bone from the NGRP sites do not resemble the narrow and V-shaped cut marks made with stone tools. Instead, they are somewhat shallow and more closely resemble marks made by bamboo tools in replicative studies (Spenneman, 1990; West & Louys, 2007). Expedient and extremely sharp, bamboo knives are routinely made and used in a range of activities in gardening and hunting (Loving, 1976; Steensberg, 1980). They also have ritual uses in headhunting ceremonies as observed by Haddon (1901) among the Kiwai and Mawatta peoples of Borneo and the Asmat (Zegwaard, 1959) and Miyanmin of New Guinea (Gardner, 1999). Shell tools might also have been used. These make shorter cut marks with interior striations, and are also typically shallower than those made by stone tools (Toth & Woods, 1989; DeGusta, 1999).

A chop mark is present on a shaft splinter from the posterior aspect of a distal left tibia, and both a cut mark and a chop mark are present on long bone splinters from the distal third of a left fibula. Location of these tool marks suggests that they were made by cutting the tendons of the flexors of the foot (flexor digitorum longus and flexor hallucis longus), which pass down the back of the distal tibia and fibula.

U-shaped grooves are present on cranial fragments from Individuals 16-1 and 16-3 and an innominate from Individual 16-1. These are relatively shallow, elongate grooves or notches with a U-shaped cross section. The U-shaped grooves vary in length, width, and the number and the orientation of the grooves relative to each other and the bone element.

Given the variability in mark morphology and location, these marks may be the products of several different taphonomic agents. Although some might be tooth furrows such as described by Milner and Smith (1989), this can be questioned for several reasons. First, the U-shaped grooves can be distinguished from chewing damage by their orientation, patterning, and lack of co-occurrence with identifiable chewing alterations like ovoid pits made by tooth cusps. Second, the grooves are present in what would appear to be extremely difficult areas to chew on, and they do not co-occur with other chewing marks on more accessible portions of the same fragments. Third, the U-shaped grooves do not match the morphology of experimentally generated marks made with pig incisors. The latter exhibit more distinct edges and near

Table 10.7. Summary taphonomy data, NGRP 46.

Category	All		Pig		Human	
	nw/nobs[a]	% w	nw/nobs	% w	nw/nobs	% w
Preservation						
Weathering scores						
Nobs	75		30		4	
Mean	1.46		1.33		0.75	
SD	1.43		1.54		0.96	
Rolling	40/70	54	13/33	39	1/5	20
Polish	3/65	5	2/33	6	1/4	25
Beveled fracture	9/71	13	1/35	3	0/4	0
Thermal alteration	8/75	11	5/35	14	1/5	20
Animal damage						
Chew marks: any	17/74	23	7/36	19	0/5	0
Chewing	13/72	18	7/35	20	0/5	0
Ovoid pits	2/72	3	0/35	0	0/5	0
Rodent gnaw	1/75	1	0/35	0	0/5	0
Tooth puncture	3/75	4	1/35	3	0/5	0
Trampling/striae	55/74	74	6/14	43	3/5	60
Tool marks						
Tool marks: any	18/72	25	10/34	29	1/5	20
Chop marks	6/71	8	2/34	6	1/4	25
Scrape marks	8/72	11	6/34	18	1/5	20
Cut marks	5/70	7	2/34	6	1/5	20
U-shaped grooves	3/15	20	0/2	0	0/1	0
Postcranial fracture						
Perimortem	38/62	61	20/29	69	5/7	71
Postmortem	24/62	39	9/29	31	2/7	29
Fracture products						
Crushing	10/60	17	6/30	20	2/4	50
Peeling	26/67	39	15/32	47	1/5	20
Incipient fracture crack	2/60	3	1/30	3	1/4	25
Percussion pits	17/68	25	8/33	24	1/4	25
Associated percussion striae	9/17	53	4/8	50	1/1	100

[a] nw = number of fragments with modification; nobs = number of fragments observable.

grooves formed by the lateral curvature of the incisor crowns. Therefore, we think that the U-shaped grooves are tool marks. They are located almost exclusively on nontubular elements, fragments of the cranium, and pelvis. The innominate fragment from Individual 16-1 has two large U-shaped grooves on the anterior surface in the iliac fossa above the auricular area. However, several large ovoid pits on the posterior (opposite) surface suggest that in this instance the grooves may be chewing related. The U-shaped groove on one parietal fragment may also be chewing damage given the proximity of chewing damage on the edge of the fragment.

Scrape marks in the anterior-distal portion of the greater sciatic notch provide a less ambiguous indicator of human agency. Scrape marks are also present on a talus fragment and on a proximal hand phalange.

Fractures and Fracture Products—Fractures in tubular infracranial elements were classified by edge shape using Marshall's (1989) categories and grouped as perimortem (i.e., having occurred at or near the time of death) or as postmortem damage inflicted to nonvital bone. Spiral, V-shaped flaking, and sawtooth fractures are counted here as perimortem; stepped, longitudinal, perpendicular, irregular, and indeterminate fractures are counted as postmortem. In the NGRP 16 assemblage, 40% of the observed fracture edges were classified as perimortem, and 60% as postmortem. Another type of perimortem damage—peeling resulting from fracturing and pulling apart of a vital bone (White, 1992)—is present on 15% of the bone in the NGRP 16 assemblage.

Analysis of perimortem and postmortem fracture patterns in the long bone fragments indicates that at least some of the damage to the ends of bones was inflicted when the bone was in a vital state, but that the shafts of the long bones were broken postinterment (Fig. 10.4). The long bones were not smashed for marrow extraction. They were interred with at least their central-most shafts intact. The ends of the bones may have been removed as part of a disarticulation process, or they may have been consumed by pigs or dogs. Cut marks and scrape marks on the leg bones and innominate of Individual 16-1 suggest disarticulation.

It is clear that these remains have been subject to considerable peri- and postmortem damage by animals, sedimentary matrix and pressure, and to some extent, human agency. The incompleteness of the skeletons, the slight distinctions in weathering and preservation between the two adult assemblages, and the patterning in elements suggest that these are two secondary burials.

NGRP 46 Taphonomy

NGRP 46 has more infracranial pig bone than the faunal assemblages from the other sites, and these taphonomic data provide a basis for comparison with the human remains from the other sites. While more representative than the mandible-

Table 10.8. Comparative taphonomy summary for Individual 23-6, other human bone, and pig bone from NGRP 23.

Assemblage component	23-6		All human but 23-6		Pig	
	nw/nobs[a]	% w	nw/nobs	% w	nw/nobs	% w
Preservation						
Weathering scores						
Nobs	121		374		313	
Mean	0.54		0.87		1.47	
SD	0.85		1.01		1.02	
Rolling/rounding	45/116	39	227/343[b]	61	147/312	47
End polish	0/130	0	5/364	1	0/310	0
Beveled fracture	0/130	0	2/361	<1	0/310	0
Thermal alteration	1/148	<1	2/410	<1	45/311[b]	14
Animal damage						
Chew marks: any	54/148	34	141/407	35	57/425	13
Ovoid pits	18/148	12	49/409	12	10/312	3
Rodent gnaw	0/148	0	0/409	0	0/313	0
Tooth puncture	3/148	2	4/409	1	0/313	0
Trampling/striae	7/131	5	65/373[b]	17	61/312	20
Tool marks						
Tool marks: any[c]	8/148	5	14/409	3	6/438	1
Chop marks	2/148	1	4/408	1	3/313	1
Scrape marks	1/148	<1	2/408	<1	0/313	0
Cut marks	1/147	<1	5/408	1	1/313	<1
U-shaped groove	5/148	3	3/295	1	2/313	<1
Postcranial fracture						
Perimortem	22/63	35	135/368	37	7/12	58
Postmortem	41/63	65	233/368	63	5/12	42
Fracture products						
Crushing	0/148	0	1/408	<1	0/312	0
Peeling	5/90	6	31/323	10	24/297	8
Incipient fracture crack	2/15	13	3/22	14	0/12	0
Percussion pits	0/148	0	10/409	2	1/313	<1
Percussion striae	0/11	0	2/10	20	0/1	0

[a] nw = number of fragments with modification; nobs = number of fragments observable for modification.
[b] Significant difference: pig versus human ($p < 0.001$).
[c] Significant difference: frequency 23-6 versus other human bone ($p < 0.001$).

dominated pig bone assemblage from NGRP 23, this is, however, a very small assemblage, as evident in Table 10.7. This site also has the smallest collection of human remains.

Preservation—Except for fish vertebrae and dog teeth, there are no complete skeletal elements from any species in the NGRP 46 assemblage. The human bone fragments (teeth excluded) are on average larger than the pig bone fragments (average 6.7 cm compared with 4.7 cm). Weathering scores for the NGRP 46 faunal remains are generally low. Thirty-two percent of the assemblage exhibits no weathering, and only 11% are weathered at stage 4 or beyond on the 0–6 scale (Behrensmeyer, 1978). The average weathering score for the entire assemblage is 1.46. Mean scores for the pig and human bone are lowest at 0.75. Rolling or rounding affects 54% of the fragments, while polish on fragment ends or high points was observed on 5%, and beveled fracture edges were observed on 13% of the assemblage. These are interpreted as the result of primarily abrasion by sediment or sandy matrix, but animal or human agents can also induce these types of modification.

Eight bone fragments (11% of the observable 75 fragments) from NGRP 46 exhibit thermal alteration. These include a phalanx fragment tentatively identified as human, two cranial fragments that are either pig or human, and five pig bone fragments (14% of the pig bone). Discoloration ranges from red to gray. Two fragments display more extreme thermal alteration in the form of cracking or crazing, but none is completely blackened or calcined.

Animal Damage—Damage from animal chewing is apparent on 23% of the NGRP 46 bone. No chewing damage is observable on any of the human bone. Both chew marks and tooth punctures are present on the pig bone. Ovoid pits are present on two bone fragments that could not be assigned to a taxonomic category: one cranial fragment and one of indeterminate anatomical origin. Rodent gnawing marks are present on one cranial fragment from a pig or human. There is substantially less chewing damage in the NGRP 46 assemblage than in the NGRP 16 assemblage, in which 61% of the bone is affected.

Tool Marks—The frequency of tool marks (25%) is greater in this assemblage than in the NGRP 16 (6%) or NGRP 23 (3%) assemblages. Ten pig bone fragments from anatomically diverse locations on the axial, cranial, and appendicular skeleton exhibit tool marks (Table 10.10). Six have scrape marks, including fragments of scapula, calcaneus, humerus, ulna, and unidentifiable long bone shaft splinters. Cut marks are present on a pig radius fragment and on a pig tibia fragment. A fragment of pig maxilla or occipital also exhibits a chop mark. U-shaped grooves are present on three fragments of unknown taxonomic affiliation. As listed in Table 10.9, a conjoined set of three fragments (9.8 cm long) from a human

Table 10.9. Tool marks on human bone from NGRP sites.[a]

Accession	Unit	Individual	Location	Chop marks	Scrape marks	Cut marks	U-shaped grooves
NGRP 16							
195	A2/B	16-1	parietal fragment				1
206	A3/B	16-1	parietal, L fragment				1
209	A3/B	16-3	frontal, near orbit fragment				1
162	A3/C	16-1	innominate, R auricular, greater sciatic notch		1		2
286	P2	na	humerus/radius SS			1	
229	A2/B	na	hand phalanx, medial SS			3	
232	A2/C	16-1	hand phalanx, proximal SS		1		
244	A3/B	16-1	hand phalanx SS			2	
360	A3/C	16-1	fibula, L SS	1		2	
424	A3/C	16-1	tibia SS	1			
696	A3/C	16-1	fibula(?) SS		1		
160	A3/C	16-1	talus, R fragment		1		
NGRP 46							
31	3/2	na	femur/tibia SS	5	6	1	
NGRP 23							
1182	2A/C-1	23-1	frontal, L superior lateral margin of zygomatic: suggests defleshing			2	
5072	2E/C	23-6	parietal(?) fragment	1			
1152	2A/C		parietal near coronal and sagittal suture junction, large grooves: suggests scalping				3
3299	2A/C	na	temporal, near mastoid		1		
3301	2A/C		temporal or occipital				2
4514	2D/C-2	23-6	temporal R petrous, proximal-distal-oriented cuts on endocranial surface			3	3
4444	2D/C-2	23-6	maxilla, grooves at base of L nasal fossa: suggests defleshing				2
4127	2D/B	23-5	mandible fragment			1	
2017	2A/C-2	23-2	vertebra C1 anterior arch, cuts oriented proximodistally: suggests decapitation			2	
4700	2E/C	23-6	vertebra, T lamina, inferior facets				1
2109	2A/C-2	na	radius/ulna/fibula SS	1			
4605	2E/C	23-6	innominate, greater sciatic notch	2			
4692	2E/C	23-6	innominate, L greater sciatic notch, posterior				2
3919	2C/C-2	na	ilium, L at anterior superior iliac spine			2	
2658	2B/C-2	na	medial hand phalanx, SS near distal end on dorsal surface			3	
2663	2B/C-2	na	medial hand phalanx, SS near distal end on palmar surface			1	
3896	2C/C-2	na	metacarpal ST		1		
4828	2E/C	23-6	femur, R SS				1
4590	2E/C	23-6	patella fragment		1		
2597	2B/C-2	23-1?2	tibia, L SS	1			
777	2A/B	na	tibia SS	1			
3062	2C/C-1	23-1?2	tibia SSP				1

[a] Unit = excavation unit; na = not applicable; SS = shaft splinter; ST = shaft tube; SSP = shaft splinter proximal half of bone.

femur or tibia shaft (accession 31) has one cut mark, five chop marks, and six sets of scrape marks. The element identification is uncertain, so the precise anatomical location of these marks cannot be determined, but this is the most intensively impacted bone from any of the NGRP assemblages.

Fractures—Types of postcranial fractures could be observed for 37 fragments with 62 fracture edges. Sixty-one percent of the fractures are interpreted as perimortem and 39% as postmortem. In the pig bone sample (15 fragments and 29 fracture edges), 69% are perimortem fractures. Of the four fragments (seven fracture edges) in the human bone assemblage, five (71%) are perimortem fractures.

Fracture Products—Two incipient fracture cracks were observed (3%). One of these is on the same conjoined set of human femur/tibia shaft fragments that have the cut marks, scrape marks, and chop marks. The second is in a shaft splinter from a pig tibia. Adhering flakes from incomplete fractures are present in less than 1% of the assemblage. Seventeen percent of the NGRP 46 bone assemblage exhibits crushing, including the conjoined set of leg bone fragments (accession 31) mentioned above and the distal end and shaft of a human first metatarsal. Six pig bone fragments also display crushing.

Peeling is evident on 39% of the fragments. This indicator of perimortem bone breakage is present on a human ulna shaft fragment and on 15 pig bone fragments from long bones, maxilla, and axial elements. Long bone fragments, vertebra fragments, and pig or human rib fragments also exhibit peeling. One-fourth of the assemblage exhibits one or more percussion pits, including eight pig bones, the human femur or tibia conjoin set (accession 31), four pig or human fragments, and four fragments from indeterminate taxa. Percussion striae associated with percussion pits are present on nine fragments.

There is no consistent or exclusive correspondence between any fracture product category and tool marks or chewing marks, but percussion pits and peeling are usually observed on fragments with tool marks. Eight of the 17 items with tool marks exhibit peeling, and seven of these also have percussion

Table 10.10. Tool marks on nonhuman bone, NGRP 46 and NGRP 23.[a]

Accession	Unit	Species	Location	Chop marks	Scrape marks	Cut marks	U-shaped grooves
NGRP 46							
133	1B/1	pig	maxilla/occipital?	1			
51	3/1	pig	scapula fragment		1		
61	3/2	pig	pelvis fragment	1			
15	1A/2	pig	tibia SS			1	
35	3/2	pig	radius SS			1	
49	3/1	pig	calcaneus fragment		1		
138	1B/2	pig	LBF ST		1		
75	3/2	pig	humerus SSD		1		
22	1A/2	pig	ulna? SS		1		
45	3/2	pig(?)	LBF SS		1		
46	3/2	p/h	femur SSP	1		1	
81	3/2	p/h	LBF SS			1	
120	2/2	turtle	carapace	1	1		
64	3/2	indeterminate	cranium?				4
66	3/2	indeterminate	cranium				1
139	1B/2	indeterminate	indeterminate				1
84	3/2	indeterminate	indeterminate	1			
NGRP 23							
4094	2D/B	pig	maxilla fragment				3
2241	2B/B	pig	mandibular condyle	1			
880	2B/C	pig	mandible ramus			4	
4039	2D/B	pig	vertebra, caudal	2			
4043	2D/B	pig	vertebra, caudal	2			
4521	2E/B	pig	indeterminate fragment				1

[a] SS = shaft splinter; LBF = long bone fragment; ST = shaft tube; SSD = shaft splinter distal region; SSP = shaft splinter proximal region.

pits. Both peeling and percussion pits also occur on bone fragments without tool marks, and in some cases they are clearly related to chewing damage. Crushing is also associated with both tool marks and chewing damage. There were no instances of incipient fracture cracks co-occurring with chewing marks. It is apparent that both human and animal activities produced fractures and fracture products in this assemblage.

In sum, the 132 fragments of bone from NGRP 46 are 42% pig bone (56 fragments; MNI = 2), 8% pig or human, and 6% human bone (eight fragments; MNI = 1). This assemblage contains more animal bone from a broader range of species than NGRP 16 and 23, and a considerably smaller proportion of human bone. There is also more anatomical diversity in the pig bone from this site, suggesting that this deposit is more likely to represent a "kitchen midden" than the other bone assemblages. The NGRP 46 bone has less evidence of animal chewing than the other assemblages, and weathering is minimal, but there is abundant damage to the bone surfaces. Perimortem fractures are more common than postmortem

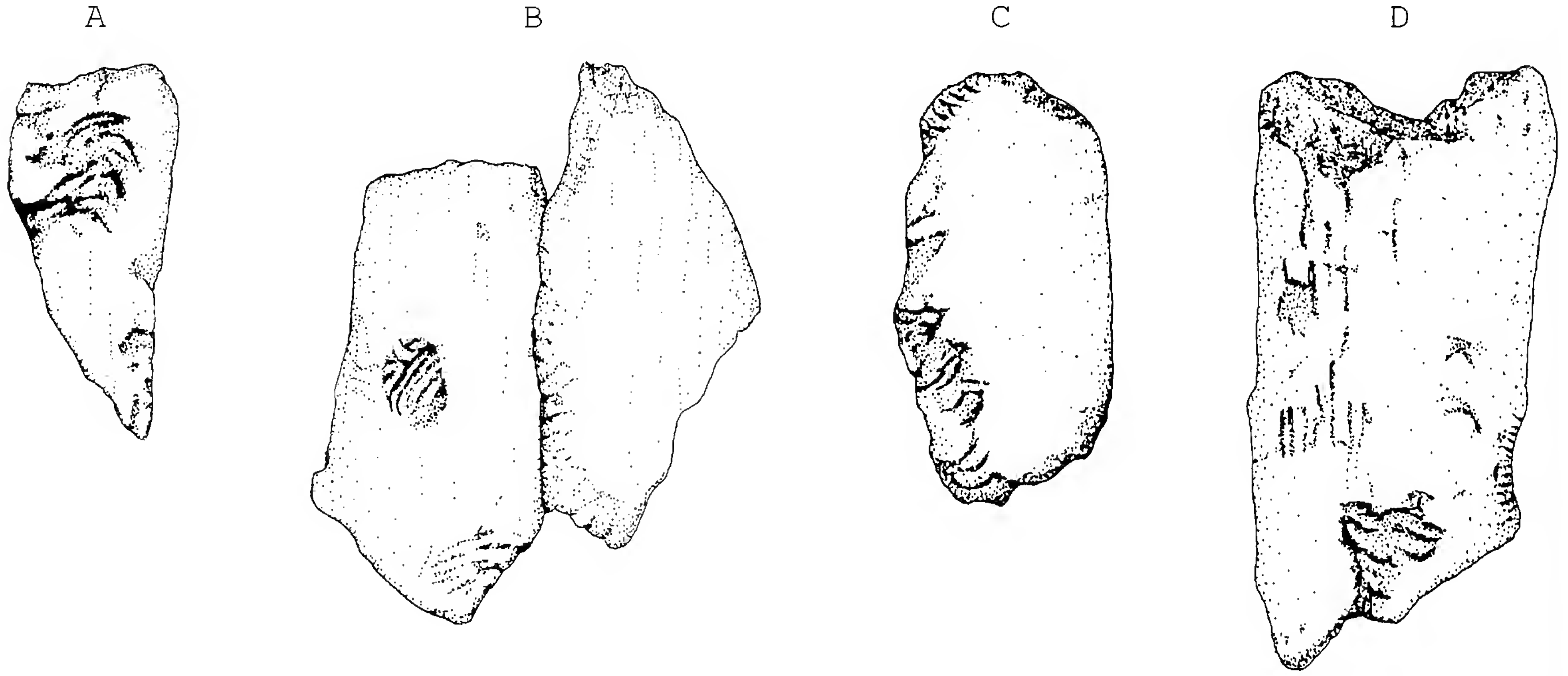

Fig. 10.3. Bone fragments. (**a**) chewing marks on a long bone shaft splinter; (**b**) conjoined weathered long bone shaft fragments with canine puncture; (**c**) long bone fragment with edge wear and chewing damage; (**d**) chewing marks, wear, and exfoliation on long bone fragment bone surface (drawings by Eric Wert, Field Museum).

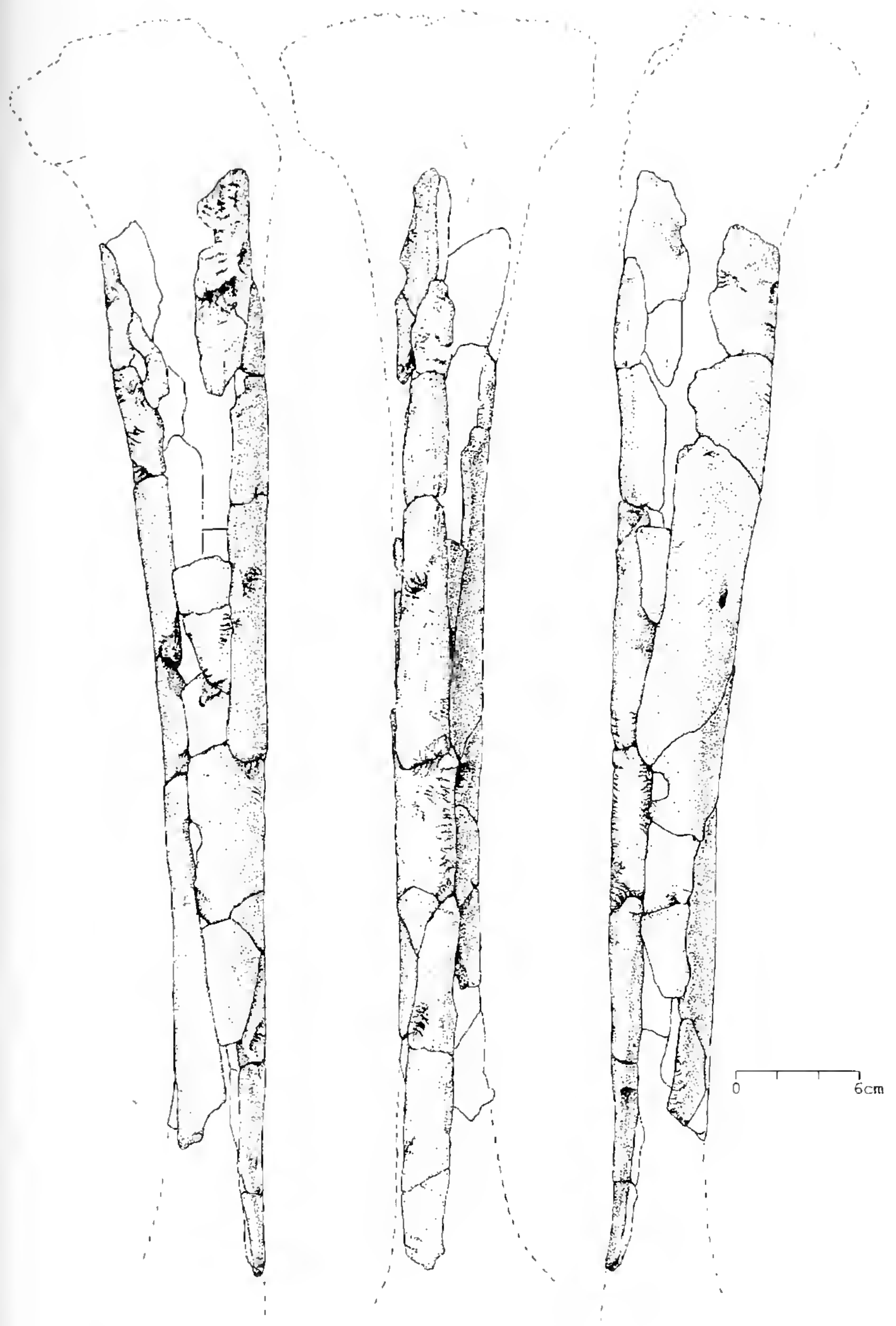

FIG. 10.4. Three views of a reconstructed tibia, NGRP 23 (drawings by Eric Wert, Field Museum).

fractures: 61% versus 39%. Scrape marks are notably frequent on the pig bones (18%). On the whole, there is more evidence of human-induced modification (tool marks) than in the NGRP 16 (25% vs. 6%) or NGRP 23 (3%) bone. These observations are indicative of human processing of the pig remains for consumption. The conjoined human femur/tibia (accession 31) exhibits a high degree of human modification, indicating disarticulation and soft tissue removal. This pattern of modification could be indicative of a secondary burial or cannibalism or both, but the overall paucity of human remains from the deposit produces an ambiguity in determining the primary human activity producing the modifications.

NGRP 23 Taphonomy

The taphonomic data for NGRP 23 are summarized in Table 10.8, which lists data on two subsets of human bone fragments: bone assigned to Individual 23-6 and the human bone excluding the fragments from Individual 23-6. Tool marks observed on human bone and on pig bone are listed in Tables 10.9 and 10.10, respectively.

PRESERVATION—The largest (unconjoined) fragment of human bone from NGRP 23 is 16.5 cm, a fragment of the left femur shaft of Individual 23-6. The largest pig bone fragment, part of a mandible, is 12.8 cm long. Mean size of the bone fragments from NGRP 23 is 2.25 cm for human bone and 1.83 cm for pig bone. The pig bone has a higher average weathering score (1.47 on the 0–6 scale) than the human bone assemblages. Among the human bone, fragments from Individual 23-6 have a lower average weathering score (0.54) than the rest of the human bone (0.87). More than half the human bone (59% of the combined assemblage of 459 fragments), and slightly less than half the pig bone in this assemblage exhibit damage due to rolling or rounding. End polish or beveled fracture edges occur on less than 1% of the human bone and were not observed on any of the pig remains.

THERMAL ALTERATION—Forty-eight bone fragments exhibit thermal alteration, 4% of the 1,145 observable fragments in the NGRP 23 assemblage. Thermal alteration is present on 14% of the pig bone, a significantly greater frequency of burning than in the human remains (<1%) from this site ($\chi^2 = 58.45$, $p \leq 0.001$). The three burned human bone fragments are a parietal or occipital fragment, a thoracic vertebra fragment, and a (possibly human) tibia or fibula shaft splinter. Most of the burned bone fragments ($n = 42$) are from pig mandibles, but there are also three pig innominate fragments that are fire-reddened. Reddening from exposure to a relatively low temperature range, between 300°C and 500–600°C (Lyman, 1994, p. 386), is visible on three pig innominate fragments and the human cranium fragment. Seven fragments are partly red, but also have more intensively burned black or gray areas. Forty-four fragments are black or partly black (4% of the 1,145 observable fragments in the NGRP 23 assemblage), indicating that they were heated at temperatures above 600°C. There are 30 gray or white fragments, indicating calcination on 3% of the assemblage. Only one bone fragment, a possibly human tibia or fibula shaft splinter, exhibits more extreme thermal alteration: cracking or checking.

Five of the thermally altered pig mandible fragments are part of conjoined sets in which all the fragments are burned. Other groups of burned fragments that were found together presumably represent a single element, although it cannot be reconstructed. This suggests that thermal alteration of pig mandibles occurred before the bones reached their present stage of fragmentation. None of the pig maxilla or other skull fragments and none of the maxillary teeth are burned. The burning on some mandibles is present on only one aspect, suggesting that if flesh remained on the mandibles, there was not enough to protect the bone from the fire. It is apparent from the anatomical distribution of the NGRP 23 pig bone and dentition assemblage that the mandibles were deposited here as intact (or as right or left portions) with teeth in situ but without the rest of the head.

ANIMAL DAMAGE—There is abundant animal chewing damage in this assemblage. Ovoid pits are present on 12% of the human bone fragments. The pits are significantly more abundant in the human bone than they are in the pig bone, 3% of which are affected ($\chi^2 = 20.19$, df = 1, $p \leq 0.001$). The 67 ovoid pits on human bone are on cranial fragments ($n = 3$), axial fragments ($n = 4$), hand and foot bones ($n = 7$), long bone fragments ($n = 42$), and unidentifiable fragments. Multiple pits (as many as four) appear on 16 fragments. Some overlap or have a linear alignment. Half pits are present adjacent to fracture edges, and on some refit specimens the pits cross fracture edges, indicating the role of chewing in bone failure. Ovoid pits appear on pig mandible and maxilla fragments and on the roots of three pig teeth. Tooth puncture marks, presumably made by pigs or dogs, are present on seven human bone fragments (~1–2%) but there are none on the pig remains. Random striations attributed to animal trampling are present on 17% of the assemblage, affecting 14% of the human bone fragments, 20% of the pig bone, and 20% of the "pig or human" bone. This type of damage is less prevalent in bone from Individual 23-6 than the rest of the human bone, but bone from this individual exhibits the same amount of chewing damage as the rest of the human bone assemblage.

TOOL MARKS—Tool marks are present on 22 human bone fragments, six pig bone fragments, and three "pig or human" fragments. The combined frequency of tool marks (chop marks, scrape marks, cut marks, and U-shaped grooves) in the entire assemblage is 3%, but individually the tool mark classes occur in 1% or less of the assemblage. Tool marks are significantly more abundant in human bone than in pig bone from the site ($\chi^2 = 6.73$, df = 1, $p \leq 0.01$). This is in part a reflection of the differences in anatomical distribution of the pig and human remains. Because this pig bone assemblage is dominated by mandibles and dentition, there are very few of the infracranial elements from pigs that would typically be expected to bear butchery marks.

TOOL MARKS ON HUMAN BONE—Tool marks on human bone (listed in Table 10.9) occur on fragments from at least four of the individuals: 23-1, 23-2, 23-5, and 23-6. Chop marks are present on a parietal fragment, an innominate fragment, and three long bone shaft fragments. Scrape marks are present on a parietal fragment, a metacarpal, and a patella. Cut marks are present on cranial, axial, and hand bone fragments, but there are no cut marks on long bone fragments in the NGRP 23 human bone assemblage. U-shaped grooves are observed on cranial and axial elements, and on two leg bone shaft splinters. Some of the tool marks can be reasonably assumed to reflect disarticulation processing: the cuts on the cervical vertebra, mandibular ramus, innominates, and lower leg. The cut marks on the facial remains suggest defleshing. Tool marks on the cranial bones suggest removal of the scalp. Additional processing of the cranium—cleaning and brain removal—is suggested by the fragment of the anterior rim of the foramen magnum and by the cut marks on the endocranial surface of a temporal bone fragment.

TOOL MARKS ON PIG BONE—Tool marks were observed on six pig bone fragments (Table 10.10). Chop marks are present on a mandibular condyle fragment and on two caudal vertebrae. A fragment of mandibular ramus has four cut marks. These are the only cut marks on bone fragments that could be confidently identified as pig. No scrape marks were observed on pig remains. U-shaped grooves are present on a maxilla fragment and on an unidentified infracranial fragment.

POSTCRANIAL FRACTURES—Thirty-eight percent of the fractures in the NGRP 23 assemblage (all species combined) are classified as perimortem, and 62% as postmortem. The human bone assemblage has approximately the same proportion: 36% perimortem and 64% postmortem fractures. In the small collection of postcranial pig elements (12 fragments), 58% of the fractures are classified as perimortem, and 42% are classified as postmortem. The "pig or human" assemblage of 18 items has more perimortem fractures than the human or pig bone assemblage, suggesting that perimortem damage may be one of the factors affecting taxonomic identifiability of the fragmentary assemblage.

FRACTURE PRODUCTS—Incipient fracture cracks are absent in the pig bone assemblage, but are present on five human bone fragments: two ulnae, one humerus and one fibula fragment, and a right-mandibular condyle fragment. Peeling (indicative of perimortem breakage) is evident on approximately 8% of the human and pig bone fragments. In the pig bone, all but one of the 24 instances of peeling is in a mandible or maxilla fragment. In the human remains, peeling is present on five ribs and one scapula fragment, two phalanges, and two metacarpals or metatarsals and on 20 long bone fragments. Crushing is present on three human bone fragments: a subadult temporal bone fragment, a thoracic vertebra body fragment, and a lunate.

PERCUSSION PITS AND STRIAE—One or more percussion pits are present on 10 human bone fragments, occurring on 10 of 446 observable fragments (2%). This is a significantly higher frequency than in the pig bone ($\chi^2 = 4.76$, df = 1, $p \leq 0.05$), in which one mandible fragment is affected. Two of the human bone fragments with percussion pits also have associated percussion striae. In the human bone, percussion pits are located on four cranial fragments.

FRACTURE PRODUCTS, TOOL MARKS, AND CHEWING DAMAGE—Co-occurrence of fracture products with evidence of animal chewing damage or tool marks on bone fragments provides some information on the origin of some of these taphonomic markers. Three of the 54 human bone fragments (5%) with one or more fracture products also have tool marks, and 15 (28%) also have chewing damage. Fracture products appear to co-occur more often with chewing damage, but this is most likely a reflection of the much higher frequency of chewing damage in the assemblage as a whole. Of the 195 human bone fragments with chewing damage, 15 (8%) also have fracture products. As with the assemblages from NGRP 16 and 46, there is no simple co-occurrence pattern that allows us to attribute all fracture products exclusively to animal or human agency.

Crushing on the petrous of Individual 23-7 co-occurs with chewing damage, indicating animal damage to these subadult remains. All the incipient fracture cracks are on fragments that also exhibit chewing damage, suggesting that these bones were chewed on while in a still-vital state. Only two of the 10 fragments with percussion pits also exhibit tool marks. Peeling co-occurs with chew marks on 12 fragments, and never with tool marks alone. This is meant to imply not that percussion pits and peeling are all animal induced, but rather that these and other fracture products can be the product of both animal and human activities and that both human- and animal-induced damage can be seen on the same bone fragment. With the exception of peeling and a single percussion pit, fracture products are rare on the pig bone assemblage from NGRP 23. None of these appears on items that also exhibit tool marks, but, as in the human bone, there is a co-occurrence of peeling and chewing marks.

The preponderance of pig mandibles in the NGRP 23 assemblage is suggestive of cultural activities rather than differential preservation and taphonomic factors. The curation of these elements is well documented in the anthropological literature for New Guinea, suggesting a relatively wide geographic distribution and long temporal depth for this practice. Michael Somare, Prime Minister of Papua New Guinea, describes the importance of pig mandibles: "A total of sixteen pigs were killed for my initiation. As is the custom at Murik Lakes, the jawbones of these pigs were all tied on a string and hung up in the men's house. A pig's jawbones are a symbol of wealth and an historical record at the same time" (Somare, 1974, p. 30).

On New Ireland, the Susurunga array the mandibles of pigs killed at specific mortuary feasts, and they serve as mnemonics for remembered deceased (Bolyanatz, 2000). Also, Bulmer (1976) documents a range of specific practices among the Kalam of the New Guinea highlands in which the mode and location for proper disposal of bone is dictated by ritual and ceremonial requirements. In typical butchering and cooking of pigs, the skulls are smashed to extract the brain, the long bones may be smashed for marrow extraction, but mandibles are generally left intact. "The mandibles, especially half mandibles ... would survive in larger numbers than other bones in the debris of cooking sites, as indeed is the case in some of the first archaeological deposits to be reported from the New Guinea Highlands" (Bulmer, 1976, p. 181). At Aibura Cave, the percentage of pig mandibles in relation to other bone is higher than expected if animals had been brought to the site before butchering. "Even today the villages preserve in their huts many mandibles of larger animals caught by hunting. If this were the practice in prehistoric times, it would explain not only why mandibles are so common, but also why they outnumber maxillae to such an extent" (White, 1972, p. 59). Pig cranial fragments and teeth are also disproportionately represented in faunal remains from the Kainapirina (SAC) locality (Green et al., 1989; Green & Anson, 2000; Smith, 2000, p. 139) on Watom Island, but other body parts are also present in these assemblages. The NGRP 23 pig assemblage offers a comparable match with these descriptions.

The human remains from NGRP 23, representing minimally seven individuals, exhibit a range of human and animal modification. The human-induced modifications could be indicative of processing during either secondary burial preparations or cannibalism, two activities that may not be mutually exclusive. The following sections examine the taphonomic signature of cannibalism along with the archaeological and ethnographic records of secondary burial and bone curation recorded in New Guinea.

Summary

Weathering, element representation, and spatial distribution indicate that the various individuals represented in the NGRP 16 and 23 assemblages were differentially preserved and represent at least two discrete depositional entities for each site. Arm bones and cranial remains are underrepresented. The locations of tool marks suggest disarticulation and other processing of human bodies, which we believe represent parts of a mortuary program. Crania were removed, leaving marks on the C1 vertebra of two individuals; defleshing the face left grooves on the base of the nasal fossa and marks on the temporals, and a fragment of the anterior rim of the foramen magnum suggests cleaning and preparation of the skull. Disarticulation of the postcranial skeleton was accomplished in part by processing the innominates—indicated by chop marks and grooves on the ilia of two individuals. With the exception of a proximal ulna, none of the long bones have ends preserved, but tool marks are rare on long bones: three chop marks on three shaft splinters. The partially reconstructable shafts, especially of the long bones that were piled up, indicate that the shafts were intact on deposition, and were not smashed for marrow extraction. Although the NGRP 46 assemblage of human remains is small, this collection does include the most heavily tool-modified element for all the sites. It is probable that the few remains from NGRP 46 represent similar mortuary behavior associated with secondary interments as at NGRP 16 and 23.

In sum, there are several traces of human modification affecting the condition and placement of the human and pig remains, suggesting that they were part of a mortuary program involving disarticulation and selective curation of skeletal elements prior to burial. But these findings do not directly address the question of whether the human bone represents food remains, or whether there are sufficient similarities in the condition of the human and nonhuman bone to support or refute a hypothesis of cannibalism. In the next section, we compare the NGRP taphonomic data to data from two sites in Fiji, summarize findings of the systematic taphonomic study of the human and pig bone from NGRP 23, and examine the data within the frameworks of proposed criteria for cannibalism.

Taphonomic Signatures of Cannibalism

The rationale for systematic taphonomic studies in the assessment of cannibalism hinges on whether human bone shows evidence of having been treated similarly to animal bones that are accepted as being food remains (Villa et al., 1986; White, 1992; DeGusta, 1999, 2000; Turner & Turner, 1999; Edgar & Sciulli, 2006). Unfortunately we cannot directly compare the modification of pig and human bone in any one of the three NGRP assemblages. The sites with relatively substantial quantities of human bone, NGRP 16 and 23, do not have sufficient or anatomically appropriate assemblages of pig bone, and the NGRP 46 assemblage of pig bone, which more clearly represents the edible portions of the pig, has only a few human bones. However, we can compare the frequencies of tool marks and thermal alteration in the human bone from NGRP 16 and 23 with the pig bone from NGRP 23 and 46 (Table 10.11) and see that the pig bone from NGRP 46 (which presumably represents food remains) has the highest frequency of all types of taphonomic damage. Compared to mammal bone (food remains) from the middens at Navatu and Vunda in Fiji, the NGRP 46 assemblage exhibits more peeling, crushing, and percussion pits.

DeGusta provides the most intensive and systematic taphonomic analysis for Oceanic skeletal assemblages aimed at identifying cannibalism. Based on his analyses of bone from two sites in Fiji, he concluded that the human bone from the midden at Navatu had been cannibalized (DeGusta, 1999) but that the human bone from the midden at Vunda had not (DeGusta, 2000).

The taphonomy data from these and from the formal burials at Vunda provide a comparative framework for the human bones from NGRP 16 and 23. The human bone from Aitape clearly exhibits more processing than the Vunda formal burials and overall less evidence of processing than the cannibalized assemblage from the midden at Navatu. Compared to the noncannibalized assemblage from the midden at Vunda, the Aitape remains have more peeling and less burning, but the same frequency of cut marks.

Table 10.12 lists the degree of bone shaft circumference preservation in tubular bone from the Aitape sites and

Table 10.11. Comparison with taphonomy of assemblages from Navatu and Vunda, Fiji Islands.

	Site								
	NGRP 23		16	46	Navatu		Vunda		
NISP	1,159	1,060	538	56	334	611	189	585	472
Specimen type	human	pig	human	pig	midden human[a]	midden mammal	midden human[a]	midden mammal	burials human
% of NISP									
Burning	<1	14	<1	14	11	29	5	9	0
Crushing	<1	0	5	20	1	1	2	1	0
Cut marks	2	<1	2	6	8	9	2	4	<1
Peeling	9	7	15	47	1	4	0	2	0
Percussion pits	2	<1	<1	24	1	1	0	1	0

[a] Cannibalized (see Navatu data from DeGusta, 1999); Vunda data from DeGusta (2000); NISP = number of individual specimens.

Navatu. This is a measure of fragmentation. The pig bone from NGRP 46 is the most fragmented, and the burials from Navatu are the most complete. Human bone from Aitape is more fragmented than the human and the nonhuman bone from Navatu, except for the better-preserved bone from Individual 23-6, which again suggests different treatment for the remains of this man.

Taphonomically, the Aitape human bone is distinctive from the animal bone found in middens at NGRP 46, Navatu, and Vunda and clearly differs from the Vunda burials. While there are some similarities with the cannibalized assemblage from Navatu, the Aitape bone is intermediate between the cannibalized and the noncannibalized human remains from the Fiji middens.

When the taphonomic characteristics of the Aitape human bone assemblages are compared with the features that have been used to characterize cannibalized assemblages (Table 10.13), the Aitape bone again seems to fall somewhere in the "maybe" zone. There are similarities: fragmentation, tool marks, missing skeletal elements, and a shared context with animal bone. But in several ways, the Aitape bone does not fit the presumed signature. The bone is mostly unburned, there are relatively few cut marks, and there is less than 1% frequency of end polish; the Aitape bones were found in middens, but they were not randomly mixed with animal bone; and there is evidence of deliberate placement of intact long bones (at least the shafts) that were furthermore not smashed for marrow extraction.

Table 10.12. Bone circumference preservation in NGRP and Navatu assemblages.

	% of NISP		
Assemblage	<50% complete	>50% but not complete	Shaft circumference complete
NGRP 46 pig	67	27	7
NGRP 16 human	83	5	12
NGRP 23 human *except* Individual 23-6	74	1	25
Navatu midden human[a]	54	7	41
Navatu mammal	51	7	42
NGRP 23, Individual 23-6	27	3	70
Navatu human burials	5	2	94

[a] Cannibalized (see Navatu data from DeGusta, 1999); Vunda data from DeGusta (2000); NISP = number of individual specimens.

Cannibalism is documented for several parts of mainland and island New Guinea but not for the Sepik coast. What are the other possible explanations for the taphonomic status of these assemblages? We suspect that the human remains in these sites, at least those from NGRP 16 and 23, are secondary deposits resulting from "the regular, and socially sanctioned removal of the relics of some or all deceased persons from a place of temporary [a few months or years] storage to a permanent resting place" (Metcalf & Huntington, 1991, p. 97). But how unusual are the Aitape human skeletal assemblages? What do the "regular burials" look like in New Guinea archaeological sites? We have no other archaeological data from Aitape to contextualize these sites or the human remains found here, so we have looked to the broader archaeological record to examine the range of contexts in which human remains have been found at archaeological sites in New Guinea.

Expanding the Interpretive Context

Human Remains from Archaeological Sites in Papua New Guinea

Relatively little is known about prehistoric mortuary practices in what is now Papua New Guinea, primarily because there has been so little archaeological research done in most parts of the country, including Aitape. By far the most commonly recorded prehistoric mortuary features are ossuaries, both prehistoric and historic. Ossuaries have been created by people in many areas of Papua New Guinea, both island and mainland. Such repositories have often been located in natural rock shelters, caves, and overhangs that may or may not be artificially modified to create niches or crypts suitable for interments. Some ossuaries in this part of the world hold only skulls, but most seem to safeguard long bones as well as skulls. Sometimes the bones have been placed in pots, large canoe bailers, *Tridacna* shells, wooden platters, or alternatively in carefully arranged piles. Other ossuaries simply have repeatedly disturbed jumbles of human bone. Except for a few rare examples of natural mummification, it is clear that the skulls and other bones were placed in their ossuaries after skeletonization of the deceased: these are usually secondary mortuary areas resulting from multistage mortuary practices.

The only well-known human remains from the Aitape region are the Aitape skull fragment dated to about 5,000 BP

Table 10.13. NGRP assemblages and cannibalism indicators.

Published sources	NGRP 23	NGRP 16
Turner and Turner (1995): emphasis on human assemblage		
1. Perimortem breakage	yes	yes
2. Cut marks	yes	yes
3. Anvil abrasions or percussion striae	no	no
4. Burning	no	no
5. Many missing vertebrae	yes	yes
6. End polish	no	no
Villa et al. (1986): emphasis on animal and human similarity		
1. Similar butchering techniques	yes	yes
2. Similar patterns of long bone breakage	?	?
3. Evidence of comparable cooking treatment	no	no
4. Identical patterns of postprocessing discard	no	no
DeGusta (1999, 2000): characteristics of cannibalized assemblage from Fiji		
1. Remains found in a midden context	yes	yes
2. Intensive fragmentation	yes	yes
3. Skeletal element distribution differs from complete skeletons	yes	yes
4. Lack of evidence for major nonhuman modification	no	no
5. Burning on more than 10% of human bone	no	no
6. Cut marks on more than 5% of human bone	no	no

(Hossfeld, 1964, 1965; see Chapter 4). These seemingly robust cranial fragments found during a 1929 mining exploration make up the frontal bone, portions of the parietals, and the left sphenoid. They were first identified as female (Fenner, 1941), but have now been reidentified as male (Chiles, 1997). These remains are of limited utility for documenting prehistoric mortuary behavior because of the lack of contextual information and additional elements. The geomorphologist James Goff (pers. comm.) thinks it likely that this person was a casualty of a prehistoric tsunami off the Sepik coast. If his surmise is correct, then these "burial" remains do not indicate intentional human mortuary activities, but instead tell us that this individual was the unfortunate fatality of a natural disaster.

West of Aitape on the Sepik coast near Vanimo, Green (1990, p. 447) has recorded what was probably a historic rather than a prehistoric ossuary: a large limestone rock shelter on the beachfront containing cranial and postcranial remains of about 25 individuals. Elsewhere, specifically at Taora rock shelter to the east of Vanimo and about 450 m from the coast, small fragments of human bone, including skull fragments and three teeth, were found throughout deposits that contained a hearth, shell midden, faunal remains, pottery, and lithic debris (Gorecki, pers. comm.). The site dates range from 6,120 ± 190 BP to 2,250 ± 70 BP (Gorecki et al., 1991).

Inland from Aitape in the western highlands fringe, two undated rock shelters in the Yuat Gorge also contained human remains. Additionally, Paul Gorecki (1989, p. 169) recorded a burial niche at the back of Ailegun rock shelter that also featured a large stone-lined hearth. The niche, a large natural feature about 1.6 m above the floor, contained the skeletal remains of at least 18 individuals. Gorecki has described the bodies as dried, nearly "mummified," coated in mud, and wrapped in sheets made from *marata* (*Pandanus conoideus*). The bundles were tied with kanda vines (*Calamas* sp.), and the skulls were painted red, with black parallel lines. Most if not all of these remains were in secondary context. Offerings scattered in the niche included a stone axe blade, betel nut bundles, and pig jaws as well as cassowary, fish, bird, and snake bones. In Luanana rock shelter, fragmentary human remains were resting on a ledge at the back of the shelter (Gorecki, 1989, p. 170).

Returning to the coast east of Aitape, excavations on the lower Ramu River have recovered minimal human remains from prehistoric midden contexts. A single tooth, a child's incisor, was found at the Dongan site (Swadling et al., 1991). Nine teeth and the left half of an adult mandible were found in a shell midden at the Akari site (Swadling et al., 1989; Turner, 1993).

Green (1990, pp. 409–426) recorded several ossuaries on the Huon peninsula coast, some of which are probably historic. These are located in small shallow caves, shelves, overhangs, and ledges. The number of individuals represented ranges from one to about 20. Some sites have only crania and some only the remains of adults, but other ossuaries have postcranial and cranial remains of adults and children. Many of the crania are painted with red or orange ochre, and some remains are placed in ceramic or, more rarely, wooden mortuary vessels.

Recent and prehistoric use of caves as ossuaries seems to have been fairly common in the central, eastern, and western highlands (White, 1972; Pietrusewsky, 1973; Bulmer, 1975; Green, 1990). Caves and niche burials with human remains in mortuary vessels are also documented for much of island Papua New Guinea, including Woodlark Island (Ollier & Pain, 1978), the D'Entrecasteaux Islands (Egloff, 1972; de Vera & Young, 1980, p. 233), the Trobriand Islands (Austen, 1939; Ollier & Holdsworth, 1968a, 1968b, 1969, 1971, 1977; Ollier et al., 1970a, 1970b, 1973; Ollier & Pain, 1978), and the Louisiade Archipelago (Ollier & Holdsworth, 1977). The great majority of these, if not all of them, are secondary burials: their placement in the ossuary followed a prior stage of mortuary treatment.

The Gulf/Massim District in the vicinity of Port Moresby on the opposite coast of the island from Aitape has the only archaeological sites with what most archaeologists would consider "regular burials": extended primary inhumations of one or more individuals, deliberately arranged with bodies intact at interment. These burials are spatially associated with habitation sites. These sites include Oposisi on Yule Island

(Bulmer, 1975; White & O'Connell, 1982), village sites on Motopure Island (Bulmer, 1975; Hope et al., 1983), Mailu Island (Irwin, 1985), and Nebira 2 (Bulmer, 1975; Pietrusewsky, 1976) and Nebira 4 (Bulmer, 1975; Kirch, 2000) on the mainland.

However, other mortuary stages or kinds of interaction with the dead are also indicated in this area. Tubular beads of human bone from Oposisi are interpreted as having been worn in horizontal pendants, either singly or stacked in a vertical series. Square and rectangular tablets of human cranial bone bear evidence of substantial use or handling, although their function is unknown (White & O'Connell, 1982, p. 200). At Mailu, a village site on an offshore island that became a regional ceramic production center (Chapter 15), one burial features a complete skeleton, extended, and placed on its back, with its arms around the cranium of a second individual for whom no postcranial remains are evident (Irwin, 1985; Kirch, 2000). Indeed, at what is currently the oldest cemetery in the Pacific, the Lapita site of Teouma on Efate Island, Vanuatu, primary burials are accompanied by the skulls of other individuals; the curation/removal of forearms, clavicles, and sternebrae is evident; and there are several types of secondary interments with particular arrangements of bone (Buckley et al., 2008, p. 91; F. Valentin, pers. comm.).

Human remains were found in excavations of megalithic structures at Otuyam C and D on Kiriwina Island in the Trobriands, but Austen (1939) states that "there was no indication that the place had ever been used as a burial ground ... there seemed to be no burial in the true sense of the word" (pp. 34–35).

The question of what constitutes a "burial" seems to be a recurring issue for archaeologists in New Guinea. The archaeological record to date yields few features that fit the classic archaeological definition of a primary, undisturbed, belowground inhumation. The small assemblages of bones and teeth that appear to be randomly scattered in middens are rarely addressed except in passing, and in the eyes of those reporting such finds, such a distribution does not confer the status of mortuary feature on midden deposits.

The Aitape deposits share some characteristics with middens: human bone is associated with shell debris and with animal bone—some with ritual overtones (the pig mandibles at NGRP 23). But the bones are not randomly distributed in the NGRP 16 and 23 deposits. The Aitape assemblages share some characteristics with the ossuaries: the apparent deposition of bundles or piles of long bones, the incomplete anatomical assemblages, and use of a natural limestone feature as at NGRP 23. And some taphonomic aspects of the Aitape assemblages resemble cannibalized bone from Fiji.

This survey of archaeologically recovered human remains from New Guinea indicates that inhumation is rare, and secondary deposits of bone are much more common. Gorecki (1979) recognized this in his survey of the treatment of human remains and specifically bone curation in the highlands of New Guinea. He used his data to suggest what archaeologists might expect to see and not see in mortuary features in New Guinea. Given the current state of knowledge, the "normal burial" seems to be groups of bones in secondary but not random contexts. In this sense, the human bone assemblages from Aitape fall well within the range of recorded contexts for human remains and more commonly recognized mortuary features. Since little is known about the taphonomic modification of the bones in the ossuaries, we look to the ethnographic accounts of mortuary ritual, particularly information on the treatment of the corpse, in order to infer the taphonomic signatures of mortuary ritual.

Mortuary Behavior in New Guinea

New Guinea is noted for extreme cultural and linguistic diversity, but New Guinea societies also present some commonalities: egalitarianism, frequent small-scale warfare, men's cults, pig feasts, garden horticulture, and often complex patterns of short- and long-range trade and exchange (Terrell & Welsch, 1990, pp. 155–156). To this list, we would add the importance of mortuary ritual and feasting:

> Mortuary feasts and exchanges are a widespread, if not universal, cultural form in Melanesia and are found, often in a considerably elaborated format, in the interior as well as on the coast. They generally emphasize, and enact, a kind of summative or definitive resolution of the deceased and his or her social relationships. (Wagner, 1989, p. 254)
>
> Death triggers the ceremonies most characteristic of Melanesia, especially of the coastal and lowland regions. Beginning with the funeral, these may culminate years later in great festivals involving dances and masked performances and the dispersing of vast amounts of pork and other food to the participants. In most societies formal funerals are held for everyone, though they may be abbreviated when the corpse is that of a baby or an old woman who lacks close kin. Although cremation is practiced in a few places, in many others the initial disposal of the body is temporary. It may be exposed on a platform or buried for a few months until decay is complete, but thereafter some or all of the bones may be subject to special treatment. This varies with local ideas about the relations between the body and soul. (Chowning, 1986, p. 356)

In discussing the comparative morphology of mortuary feasts, Wagner (1989) observes a "remarkably uniform general schema" (p. 255) in most of the Massim region and considerably beyond. The general scheme is a three-phase one:

> The series of mortuary feasts is differentiated into usually, and at least, three stages or phases of feasting each including one or more named events. The sequence as a whole organizes the stages by which a community at large or particular classes of people involved in the mourning are released from taboos or restrictions assumed at the time of death. An initial stage of feasting begins at death, or immediately after burial, and may last from a few days to a week or more; a second stage, from a month to a year after the first, follows; and the final stage comes some time after this, upward of a year to a much longer time after death. (Wagner, 1989, p. 255)

Another common aspect of mortuary behavior is the curation of skulls and a surprisingly wide range of other bones (e.g., Aufenanger, 1961; Gorecki, 1979). Most often mentioned are the mandible, radius, and other long bones:

> While the primary mortuary emphasis in many Melanesian societies was how to keep ghostly wrath at bay, the positive

power of the deceased is sometimes also harnessed.... Selected societies in most major parts of Melanesia kept parts of the skeleton, particularly the skull of deceased adult men, as relics. In many societies, skeletal relics were carefully preserved as important sacrae in cult houses or sacred sites, sometimes as part of elaborate ritual proceedings or displays. (Knauft, 1999, p. 59)

> The fate of the bones of the dead varies with the sort of continuing relations desired between their former owners and the living, but often they are deposited in sanctuaries such as caves, or in structures that serve as temples in which the bones will be a focus for future rituals. (Chowning, 1986, p. 357)

Gorecki's (1979) study of patrol reports for the Mount Hagen area revealed accounts of inhumation, cremation, mummification, and secondary disposition after exposure on platforms, in trees, and after interment in temporary graves. He suggested that in addition to ossuaries, the archaeological record of mortuary behavior in the highlands could include graves with bones missing as a result of curation, pits with single bones, graves that look like earth ovens where pigs had been cooked on top of the grave, and graves with wood or stone structures associated. Bones were removed from graves, replaced in graves, painted, washed, smoked, polished, and made into tools, ornaments, and weapons.

Here we expand on Gorecki's work and address the taphonomic implications of various aspects of ethnographically documented mortuary ritual in mainland and island New Guinea. There is variability in procedure and detail, but most of the examples are of the three-stage processes, and the ethnographic data mirror the archaeology in the prevalence of ossuaries in natural features as the site of final disposition for skeletal remains. Furthermore, there are clearly social and demographic differences in mortuary treatment. Several accounts mention differential treatment of warriors, infants, children, old people, and women, leading to the general impression that adult males probably received the most elaborate treatment, and that ossuaries or other places of interment may be age graded or have internal demographic distinctions.

The curation of the skull, mandible, and radius or other long bones seems to have been fairly common, and village-specific curation practice is recorded in ethnographic accounts of mortuary ritual in the Aitape area. As examples of the uses of curated remains, a typical man's bag from the Sepik coast in the Lewis collection at the Field Museum contains an array of bone and shell tools, betel nut–associated paraphernalia, and a magic bundle wrapped around a human radius, while a woman's bag contains her bone needles, shell scrapers, hairpins, and a polished human mandible.

The following are descriptions of mortuary practice in the early 1900s at three villages near Aitape as reported in the diaries of A. B. Lewis.

Sissano—Interment with later exhumation of the skull and radii (Welsch, 1998, p. 146):

1. For one and a half to two days before burial, the body is placed in a nearly upright position in the house, supported by the house ladder or similar object. Here people come to look and mourn. The body is fitted out in the individual's best cloths and ornaments.
2. Bodies are wrapped in coconut leaves, then in *nibung* (palm sheath), tied with bush rope, and then buried under the house.
3. After a period of time, the skull and radii are exhumed. The skull is placed in the men's house. The radii are taken by the two nearest relatives, kept as magical protectors or charms, worn on the breast shield in battle, carried on canoes to produce wind, and so on.

Arop—Decomposition in house, interment, and later exhumation of skull and radii (Welsch, 1998, p. 146):

1. In Arop, the dead are not buried, but are wrapped and placed over a small fire in the house.
2. *Nibung* leaf wrapping is so arranged that the fluid from the body is caught in a vessel to be mixed with sago and eaten by the deceased's nearest relatives.
3. The body remains there with the family for at least a year, until it has completely decayed. Then the skeleton is buried, but the skull and radii are kept out. The radii are used as charms.

Tumleo—Interment with later exhumation of skull and femora (Parkinson, 1979, pp. 88–90):

1. Burial in or adjacent to the house.
2. After a long time, perhaps three years, the body is disinterred. The skull and femora are placed in the *alol* (men's house).
3. Some bones are taken to wear as ornaments or as charms.

These practices are mirrored in the NGRP 23 assemblage. A composite of all the cranial remains from the site gives an MNI of one. There are only two radii represented, with an MNI of two. Two femora and two ulnae are represented, both with an MNI of one. Element underrepresentation is also evident in the NGRP 16 assemblage. Loss of small elements seems likely, for these could have been left in the original transit grave, at the exposure site where they could have been scavenged by pigs, dogs or other animals or lost in the process of moving the bones to their final location. But not *all* the skulls were curated, nor were all the mandibles. As the weathering and taphonomic data indicate, not all individuals represented in the NGRP human bone assemblages were subject to the same procedures, possibly a reflection of age and gender-based distinctions in mortuary practice.

Of particular relevance to our study of the potential taphonomic signatures of mortuary ritual are the descriptions of how corpses were left to decompose—in trees, on platforms, or in graves above or below ground. In these instances, skeletonization and eventual disarticulation were allowed to take place naturally, in which case the reduction of the corpse to a package or bundle of bones could be done with a minimum of tool use provided that there had been sufficient decomposition of the connective tissue.

Vial (1936) describes a method for removing the scalp by attaching a springy stick, which gradually pulls off the scalp as a body decomposes on the exposure platform. This procedure would not leave marks on the skull. Aufenanger (1961, p. 870) describes a similar technique for removal of the mandible in the highlands, which again would not leave marks on the bone. Exceptions would be the removal of the soles of the feet, removal of fingers, and any other procedure prior to the decomposition of connective tissue, such as the early "excision" of elements from newly buried individuals in the Trobriand Islands, a procedure vividly described by Malinowski (1987).

There are more tool marks associated with disarticulation in the Aitape bones than we would expect if curation and secondary disposition followed natural decomposition and complete skeletonization. Lewis's description of mortuary practice in Sissano indicates that they exhumed the skull and radii from burials underneath the house, but there is no clear indication of how much time elapsed before their removal. Even if some force was needed to acquire the relics, this does not explain the tool marks on the innominates. In this light, compared to what we might expect given some of the highlands descriptions, the Aitape bones are more suggestive of intentional disarticulation, which could be seen as evidence of butchery and cannibalism. But the human bones at NGRP 16 and 23 were not randomly deposited, and the stacks of long bones indicate deliberate placement.

While these assemblages do not resemble what we ourselves typically think of as considerate burials, they appear much more so in the context of New Guinea. The combination of body processing and culturally sanctioned secondary interment suggests that, if cannibalized, these assemblages resulted from ritually-based endocannibalism and secondary interment rather than insult-oriented exocannibalism and disrespectful discard. Additionally, the Aitape archaeological assemblages are separated from the ethnographically recorded activities by 1,200 years, and a degree of diachronic variation in mortuary behavior might be expected (i.e., greater processing marks and intentional disarticulation at earlier times than in Lewis's day).

NGRP 23 may be interpreted as the secondary or possibly the primary burial of an adult male, burial 23-6, and the secondary interments of other, possibly related individuals. The stack (previously a bundle?) of long bones supports the suggestion that the remains of the other individuals were moved from somewhere else. Different mortuary treatment for men, women, and children is suggested by the differential element representation and preservation/weathering in the two portions of the assemblage. Whether this represents only the first/transit grave for burial 23-6 and later stages of mortuary treatment for the others is not known, but it seems evident that he was placed in the small rock crevice as a more complete individual than the others whose bones were moved from elsewhere or at least rearranged.

Below we summarize—and admittedly oversimplify—the ethnographically documented array of mortuary practices and implications for what we may see in the bioarchaeological record.

Aspects of Ethnographically Documented Mortuary Practice: Taphonomic Implications

1. Exposure on a platform or in a tree in the bush: evidence of weathering, predation by pigs or dogs (i.e., chewing and trampling marks), perhaps very few marks of disarticulation or processing, and possible loss of skeletal elements.
2. Transit grave/temporary interment: susceptibility to pig and dog predation with modification to or loss of skeletal elements.
3. Removal of skull and other elements: prior to skeletonization, this could produce tool marks on the cranium and C1 vertebra; after skeletonization and sufficiently advanced decomposition, there may be no tool marks resulting from disarticulation.

FIG. 10.5. Basal view of skull with modification of the foramen magnum: chipping off of the occipital condyles, and beveling of the posterior margins of the foramen (J.F.G. Umlauff Collection, 1913; FMNH neg. no. A43531).

4. Curation: missing elements/incomplete burials, concentration or bundling of elements (e.g., stack of long bones), polish from use (e.g., amulet or ornament), holes drilled in teeth or mandible for stringing as ornaments, holes drilled in skull for rearticulation of mandible and/or hanging the skull or "threading" on a pole for display, and polish or enlargement of foramen magnum during cleaning or preparation for display (Stodder, 2005, 2006), as shown in an historic cranium in Figure 10.5.
5. Preparation, reductive modification: tool marks (e.g., cut marks or scrape marks) resulting from removal of ears, nose, skin; thermal alteration from cleansing by smoking; and weathering from exposure as a part of cleaning.
6. Preparation, additive modification: pigment, pitch, wax, and other media applied to skull or other elements for kin identification and sanctification purposes (Stodder, 2007).
7. Secondary burial: different patterns, depending on whether the burial occurs before or after decomposition; all or specific elements may be present, depending on whether the whole body or certain elements are moved.
8. Ossuary or final grave contents: variability in element representation (e.g., all elements, just the skull, or all elements except the skull and other curated bones), possibly individual remains are placed together in a container or bundle, and probability of two different final locations for the curated and noncurated portions of the same individual.
9. Ossuary demographic composition: locational distinctions based on age or sex.

Whether any portion of any of the individuals represented in the Aitape sites was consumed by the living really cannot be conclusively answered. The ethnography of mortuary practice in Melanesia and New Guinea encompasses myriad different forms of cannibalism—ranging from the ingestion of the fluids from decomposition to the butchery and consumption of "other" humans who are treated as pigs, not men. We do not know whether there was some form of cannibalism on the Sepik coast at around AD 700. It is clear that certain aspects of mortuary practice have very deep antiquity in Melanesia, and comparing these assemblages and the ethnographic descriptions of mortuary practice suggests that we may be seeing continuity in specific aspects of mortuary activity among people living on the Sepik coast for over a millennium.

Taphonomy is an extremely useful way to systematize the analysis and interpretation of the various agents and processes that inflict damage to bone before we come to study an archaeological assemblage in the laboratory, but counts of cut marks and quantitative data alone cannot tell us the intentions of those who lived long ago or the motives for specific procedures in their treatment of the dead (Rautman & Fenton, 2005; Stodder, 2008). It is increasingly clear from this and other studies of modified human bone assemblages from the Pacific (De Gusta, 1999, 2000; Steadman et al., 2000; Antón & Steadman, 2003; Cochrane et al., 2004; Pietrusewsky et al., 2007) that the so-called universal taphonomic signature of cannibalism (Turner & Turner, 1995, 1999) is far from universal, and that cannibalism can be constructively viewed as part of the continuum of local or regional mortuary practice (Stodder, 2008).

We do not see a perfect match between any ethnographically described mortuary programs and the context and condition of the Aitape bones, just as the assemblages do not taphonomically match other assemblages believed to represent incidents of cannibalism. Given the location of the NGRP sites, it is difficult to point to one ethnographically documented group or even geographic area that we would predict to be most similar to Aitape around AD 700. There is clear evidence of prehistoric contact between the coast and the highlands, the foothills, the Sepik, and the Admiralty Islands (Bulmer, 1975; Terrell & Welsch, 1990; Welsch et al., 1992; Terrell, 1998), and trade should not be assumed to have been limited to material goods. Roscoe (1989, p. 219) writes that the societies of the Sepik Basin engage in an import of artistic and material culture and trade in discrete cultural and symbolic items and styles that are treated as though they were transactable goods. We can envision a flow of material and nonmaterial cultural traits, including aspects of mortuary ritual, between Aitape and an array of other communities along the coast, inland, upriver, and out to the islands of the Bismarck Archipelago and beyond.

Seen in this broader interpretive framework, the blend of contextual and taphonomic features in the Aitape bone assemblages seem in keeping with widespread mortuary practices and with the flow of innovation and tradition across the voyaging corridor and this island continent. As a place of rich and diverse cultural traditions with an equally rich ethnographic and ethnohistoric record, New Guinea provides a valuable model for expanding the range of evidence that we can usefully encompass to interpret the archaeological record of mortuary practice. We hope that this dual approach of taphonomy and contextual analysis demonstrates some effective ways to elucidate the various processes and ritual programs that create the patterns we see in archaeological assemblages.

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Chapter 11: Analysis and Interpretation of Invertebrate Remains

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Abstract

Invertebrate remains recovered during excavations on the Sepik coast of Papua New Guinea in 1996 were analyzed. The main excavations took place in the Aitape hills, ~2 km inland from the current coastline, and on Tumleo Island, ~3 km off the coast. Remains of 72 mollusk, one arthropod, and two echinoderm species were identified. Forty-six of these are marine, 19 are from freshwater or brackish water and mangrove habitats, and 11 are terrestrial. A complete list and figures of most species are given. Analysis of the recovered remains suggests that in the Aitape hills, mollusk species gathered in freshwater and brackish water habitats were exploited extensively, while marine species played an insignificant role as a food source. Conversely, on Tumleo Island, most freshwater species found on the mainland are absent. Only a limited number of species inhabiting the interface of salt water and freshwater, such as mangrove swamps and estuaries, are present in considerable quantities. In addition, marine species were likely to have played a larger role as a food resource. Artifacts made from invertebrate remains are described and pictured.

Introduction

This study was undertaken to analyze the invertebrate remains recovered during the excavations on the Sepik coast of Papua New Guinea in 1996. The principal materials examined are from three sites: NGRP 16 and 23 in the Aitape hills and NGRP 46 on Tumleo Island (Chapter 6). NGRP 16 and 23 are single-component sites having no observable chronological variation from top to bottom and may have been occupied about 1,300–1,200 years ago. In contrast, the Tumleo excavations retrieved remains covering a time span of roughly 1,500–2,000 years (Chapters 6 and 14). At each site, test pits were excavated in stratigraphic units identified by soil color and texture together with 10–15-cm "spit" subdivisions within these soil divisions. The entire faunal samples from NGRP 16 and 23, as well as representative stratigraphic samples from NGRP 46, were brought to the Field Museum of Natural History for analysis. Also included in this study are a few shells collected at other mainland site locations in 1996 (Table 11.4).

The geologic history of this area over the past ~6,000 years can be described briefly as a northward advancement of the shoreline, a slow process of progradation and infilling that can still be seen in action in the changing modern lagoonal systems behind the beaches at Malol, Sissano, and Serra west of Aitape. We suspect that prior to the stabilization of world sea levels ~6,000–7,000 years ago, there were high, fairly steep islands offshore formed by tectonically uplifted marine reef systems and other islands farther offshore comprising flat, slightly elevated coral platforms. Tumleo is one of the latter. The former were eventually captured or absorbed by the advancing New Guinea shoreline and now form the steep hills around Aitape (Chapter 6).

Examination of satellite imagery, aerial photographs, and land system maps of the Aitape–Ambunti area (Haantjens, 1972) shows this progressive pattern of infilling. Directly south and east of the Aitape hills is an area of fan plains, levees, and back plains with mainly free drainage. To the west are areas of alluvial floodplains and freshwater swamps. During certain seasons of the year today, this part of the coast can become waterlogged enough to remind local residents of the shallow lagoons that once existed there that are still mentioned in local oral traditions.

One goal of this study was to establish an invertebrate species inventory for these excavated sites that would serve as a useful species guide when further archaeological work is done at Aitape and elsewhere on the Sepik coast. We also had several basic questions in mind about these invertebrate remains that we hoped to answer through laboratory analysis. What species of invertebrates were found at NGRP 16, 23, and 46? What types of environments did these species come from? Which among them might have been gathered by people and brought to these three former settlement locations as food?

Materials and Methods

Invertebrate remains recovered during the test excavations in the Aitape hills (NGRP 16 and 23) were identified and analyzed quantitatively at the Museum. Because of the large quantities of invertebrate remains found at NGRP 46 in 1996, only samples could be brought back to the Museum for study. These samples have only been analyzed qualitatively; that is, we were not able to estimate the relative stratigraphic frequencies of the identified species (Table 11.3).

Identification

Identifications were made using the literature cited here for each taxon and the reference collections of the Division of Invertebrates, Zoology Department, at the Museum. All identified invertebrate taxa are enumerated in the following taxa list: molluscan taxa are listed in systematic order by families (for gastropods, see Bouchet & Rocroi, 2005; for bivalves, see Mikkelsen & Bieler, 2007) and alphabetically within families. An attempt was made to use nomenclature reflecting current taxonomy. Popular shell identification books often use outdated names, and, moreover, scientific names in mollusks can be controversial—and change frequently with advances in taxonomic research. Therefore, selected references are given for taxa identified to species level to clarify our usage of names.

Assignment to Ecological Groups

No direct scientific observations of the ecology of the mollusk species currently living in the environs of the excavation sites were made during fieldwork. Therefore, the identified species were assigned to one of three ecological groups on the basis of information from the cited literature:

Terrestrial—Land snails.

Freshwater/Brackish Water/Mangrove (F/B/M)—Species of freshwater streams, ponds and lakes, brackish estuaries, and mangrove swamps. Many of the taxa included in this group are tolerant of a variety of environmental conditions. Many of the species inhabiting primarily freshwater streams are also frequently found in brackish habitats, and some of these estuarine species occur in mangrove swamps as well. It was impossible to determine in which exact habitat type many of the specimens in the archaeological record had lived. Therefore, all these taxa are here subsumed under one group heading.

Marine—Species from fully marine habitats without freshwater influence, such as coral reef areas.

Quantification

Specimens of taxa present were counted for each layer within each square at sites NGRP 16 and 23.

Gastropods—Generally, each shell was counted as one individual. Opercula were counted as individuals in the absence of shells (Turbinidae). The long and narrow shells of the genera *Faunus* and *Melanoides* were often fragmentary, and it could be possible that two or more fragments belonged to a single individual. In this case, apical fragments and fragments having the aperture preserved were counted separately. The higher count was taken as the number of individuals and was added to the number of complete specimens counted.

Bivalves—For each layer within each square, valves with the hinge preserved were compared with each other as well as with valves of the same taxon in adjacent squares and layers. If two valves were found to belong together, the two were counted as one individual. If the two matching valves were found in adjacent layers of the same square, the individual was counted for the upper layer. If the two matching valves were found in adjacent squares of the same layer, the individual was counted for the square to the east. All nonmatching valves with preserved hinges were counted as one individual each. Fragments without hinge preservation were pooled and weighed for each layer within each square. The weight was divided by the average weight × 2 of all complete valves of the taxon/taxa in question recovered at sites NGRP 16 and 23. The resulting number (rounded to the next integer) was taken as the number of individuals. Numerous recovered fragments could be assigned to the corbiculid genera *Batissa* or *Geloina*, but it was impossible to decide whether the fragments were of either one or both genera. Such fragments were counted as described above and listed as "*Batissa/Geloina*." If *Batissa/Geloina* fragments were recovered from a square/layer but were fewer than necessary for the calculation of one individual, the presence of *Batissa/Geloina* in this square/layer is indicated with the entry of "0" in the tables.

Listing of Taxa Observed

Phylum MOLLUSCA

Class POLYPLACOPHORA

Polyplacophora Figure 11.1a

NGRP Sites—16 and 23.

Ecology—Marine; on hard substrates.

Remarks—The shell of the Polyplacophora consists of eight articulated plates. A total of five plates have been found in the current study, representing one or possibly two (one fragmentary) posterior valve(s) and three or four middle plates. Judging by their size, the five plates seem to come from at least two individuals.

Class GASTROPODA
Family Turbinidae

Turbo argyrostomus Linnaeus, 1758; Figure 11.1d.

Turbo (*Marmarostoma*) *argyrostomus*: Cernohorsky, 1972, p. 45, pl. 9 (11).

Turbo (*Marmarostoma*) *argyrostomus*: Wilson, 1993, p. 105, pl. 12 (1, 3).

Turbo (*Marmarostoma*) *argyrostomus*: Okutani, 2000, p. 95, pl. 47 (28).

NGRP Site—46.

Ecology—Marine; intertidal zone to 30 m deep, on rocks (Okutani, 2000, p. 95).

Turbo chrysostomus Linnaeus, 1758; Figure 11.1b.

Turbo (*Marmarostoma*) *chrysostomus*: Cernohorsky, 1972, p. 46, pl. 9 (10).

Turbo (*Marmarostoma*) *chrysostomus*: Wilson, 1993, p. 106, pl. 12 (4).

NGRP Site—16.

Ecology—Marine; intertidal and shallow sublittoral zones of coral reefs (Wilson, 1993, p. 106).

Remarks—Only one operculum was found; however, this has the sculpture characteristic for this species well preserved.

Turbo marmoratus Linnaeus, 1758.

Turbo marmoratus: Cernohorsky, 1972, p. 44, pl. 9 (6, 7).

Turbo (*Turbo*) *marmoratus*: Okutani, 2000, p. 95, pl. 47 (26).

NGRP Site—46.

Ecology—Marine; 10–30 m deep, on rocks (Okutani, 2000, p. 95).

FIG. 11.1. (**a**) Polyplacophora, valves, NGRP 23/2C/B; (**b**) *Turbo chrysostomus*, operculum, 16/C2/C; (**c**) *Turbo* cf. *petholatus*, operculum, 16/B1/C; (**d**) *Turbo argyrostomus*, 46/1A/5/B.

REMARKS—Only one fragment in our sample, showing the characteristic tubercules of this large species.

Turbo* cf. *petholatus Linnaeus, 1758; Figure 11.1c.

Turbo petholatus: Cernohorsky, 1972, p. 44, pl. 9 (5).
Turbo petholatus: Wilson, 1993, p. 104, pl. 12 (10).
Turbo (*Turbo*) *petholatus*: Okutani, 2000, p. 95, pl. 47 (24).

NGRP SITES—9, 16, 23.
ECOLOGY—Marine; intertidal and shallow sublittoral zones to 30 m deep; coral reefs and rocky shores (Wilson, 1993, p. 104; Okutani, 2000, p. 95).
REMARKS—Several *Turbo* opercula could not be attributed to either *T. argyrostomus* or *T. chrysostomus*. They resemble the operculum of *T. petholatus* with its smooth center and traces of fine granulations at the margins and with its rapidly increasing spiral on the inner surface. Because the opercula found are eroded to various degrees, they are attributed to *T. petholatus* with some reservation.

Family Trochidae

Tectus niloticus (Linnaeus, 1767); Figure 11.15c, d.

Trochus niloticus: Wilson, 1993, p. 90, pl. 7 (16).
Tectus niloticus: Okutani, 2000, p. 63, pl. 31 (46).

NGRP SITES—14, 16.
ECOLOGY—Marine; intertidal and shallow subtidal zones, on rocks (Wilson, 1993, p. 90; Okutani, 2000, p. 63).
REMARKS—Pieces of worked shell of this species were found at sites NGRP 14 (Fig. 11.15d) and NGRP 16 (Fig. 11.15c).

Trochus sp.

NGRP SITE—16.
ECOLOGY—Marine.
REMARKS—Only small fragments were found, allowing identification only to genus level.

Family Neritidae

Nerita rumphii Récluz, 1841; Figure 11.2a.

Nerita (*Linnerita*) *rumphii*: Okutani, 2000, p. 105, pl. 52 (20).

NGRP SITES—16, 23, 46.
ECOLOGY—Marine; intertidal rocky or boulder bottom with sand patches (Okutani, 2000, p. 105).

Neritina pulligera (Linnaeus, 1767); Figure 11.2b.

Neritina pulligera: van Benthem Jutting, 1956, p. 307, fig. 24.
Neritina pulligera: van Benthem Jutting, 1963a, p. 424.
Neritina (*Neritina*) *pulligera*: Okutani, 2000, p. 105, pl. 53 (22).
Neritina (*Neritina*) *pulligera*: Starmühlner, 1976, p. 531, pl. 11 (104–110), pl. 12 (123–128).

NGRP SITES—16, 23.
ECOLOGY—Freshwater; middle and lower reaches of streams and rivers, downward to the highest parts with tidal influence; on stones (van Benthem Jutting, 1956, p. 308; Starmühlner, 1976, p. 533).

Neritina waigiensis Lesson, 1831; Figure 11.2c.

Neritina waigiensis: van Benthem Jutting, 1956, p. 299, fig. 26.
Neritina waigiensis: van Benthem Jutting, 1963a, p. 426.

NGRP SITES—16, 23.
ECOLOGY—Freshwater and brackish water and rivers but has also been found in ditches and swamps (van Benthem Jutting, 1963a, p. 427).

Neritodryas cornea (Linnaeus, 1758); Figure 11.2d.

Neritina cornea: van Benthem Jutting, 1956, p. 291, fig. 16.
Neritodryas cornea: van Benthem Jutting, 1963a, p. 419.

NGRP SITES—16, 23.
ECOLOGY—Freshwater; in rivers (van Benthem Jutting, 1963a, p. 421).

Neritodryas subsulcata (Sowerby II, 1836); Figure 11.2e.

Neritodryas subsulcata: van Benthem Jutting, 1956, p. 294, fig. 18.
Neritodryas subsulcata: van Benthem Jutting, 1963a, p. 422.
Neritodryas subsulcata: Starmühlner, 1976, p. 509, pl. 9 (62–63), pl. 10 (80–81).
Neritodryas subsulcata: Okutani, 2000, p. 107, pl. 54 (33).

NGRP SITES—16, 23.
ECOLOGY—Freshwater; upper reaches of rivers (Okutani, 2000, p. 107).

Family Neritopsidae

Neritopsis radula (Linnaeus, 1758); Figure 11.2f.

Neritopsis radula: Cernohorsky, 1972, p. 52, pl. 11 (11).
Neritopsis radula: Wilson, 1993, p. 38, pl. 2 (13a, b).
Neritopsis radula: Okutani, 2000, p. 101, pl. 51 (1).

NGRP SITES—46.

FIG. 11.2. (**a**) *Nerita rumphii*, NGRP 16/B3/B; (**b**) *Neritina pulligera*, 16/C3/B; (**c**) *Neritina waigiensis*, 16/A1/C; (**d**) *Neritodryas cornea*, 16/A3/B; (**e**) *Neritodryas subsulcata*, 16/A1/A; (**f**) *Neritopsis radula*, 46/A1/5/1.

ECOLOGY—Marine; sublittoral zone; submarine caves and cryptic habitats (Wilson, 1993, p. 38; Okutani, 2000, p. 101).

Family Cyclophoridae

Cyclotus hebraicus hebraicus (Lesson, 1831); Figure 11.3a.

Valvata hebraica Lesson, 1831, p. 347, pl. 13 (8).
Cyclotus hebraicus hebraicus: van Benthem Jutting, 1963b, p. 684.

NGRP SITES—16, 23.
ECOLOGY—Terrestrial.

Lagochilus sp.

NGRP SITE—16.
ECOLOGY—Terrestrial.
REMARKS—Only one broken shell and several aperture fragments.

Family Pupinidae

Pupinella tapparonei Brazier in Hedley, 1891; Figure 11.3b.

Pupinella tapparonei Brazier in Hedley, 1891, p. 106, pl. 12 (36).
Pupinella tapparonei: van Benthem Jutting, 1963b, p. 687.

NGRP SITES—16, 23.
ECOLOGY—Terrestrial.

Family Diplommatinidae

Diplommatina sp.

NGRP SITE—16.
ECOLOGY—Terrestrial.
REMARKS—Only a single, damaged shell in soil that fell out of larger shells.

Family Cerithiidae

Cerithium coralium Kiener, 1841; Figure 11.3c.

Cerithium coralium: Houbrick, 1992, p. 61, figs. 37–41.
Cerithium coralium: Okutani, 2000, p. 117, pl. 58 (15).

NGRP SITE—16.
ECOLOGY—Estuarine/brackish water/mangrove (Houbrick, 1992, p. 65).

Clypeomorus bifasciata bifasciata Sowerby, 1855; Figure 11.3d.

Clypeomorus bifasciata bifasciata: Houbrick, 1985, p. 23, figs. 10–17.
Clypeomorus bifasciata: Okutani, 2000, p. 119, pl. 59 (28).

NGRP SITES—16, 23.
ECOLOGY—Marine; in the high intertidal zone, usually on hard or loose rocky substrates, occasionally on softer substrates; less common in estuarine habitats such as mangrove swamps (Houbrick, 1985, pp. 33–34; Okutani, 2000, p. 119).

Family Turritellidae

Turritella terebra (Linnaeus, 1758); Figure 11.3e.

Turritella terebra: Wilson, 1993, p. 140, pl. 14 (13).

NGRP SITE—16.
ECOLOGY—Marine; soft substrates.

Family Potamididae

Telescopium telescopium (Linnaeus, 1758); Figure 11.3f.

Telescopium telescopium: Houbrick, 1991b, p. 291, fig. 1.
Telescopium telescopium: Okutani, 2000, p. 133, pl. 66 (8).

NGRP SITE—16.
ECOLOGY—Estuarine/brackish water/mangrove; intertidally on soft, muddy substrates associated with mangrove forests (Houbrick, 1991b, p. 300).

Terebralia palustris (Linnaeus, 1758); Figure 11.3g.

Terebralia palustris: Houbrick, 1991b, p. 305, fig. 7.
Terebralia palustris: Okutani, 2000, p. 133, pl. 66 (7).

NGRP SITE—16.
ECOLOGY—Estuarine/brackish water/mangrove; in brackish water on coastal mudflats in mangrove regions (Houbrick, 1991b, p. 310).

Family Pachychilidae

Faunus ater (Linnaeus, 1758); Figure 11.3h.

Faunus ater: van Benthem Jutting, 1956, p. 380, figs. 1, 8.
Faunus ater: van Benthem Jutting, 1963a, p. 464.
Faunus ater: Brandt, 1974, p. 197, pl. 14 (60).
Faunus ater: Houbrick, 1991a, p. 38.

NGRP SITES—16, 23, 46.
ECOLOGY—Freshwater and slightly brackish water in the lowlands, such as creeks, small rivers, and lagoons, and in

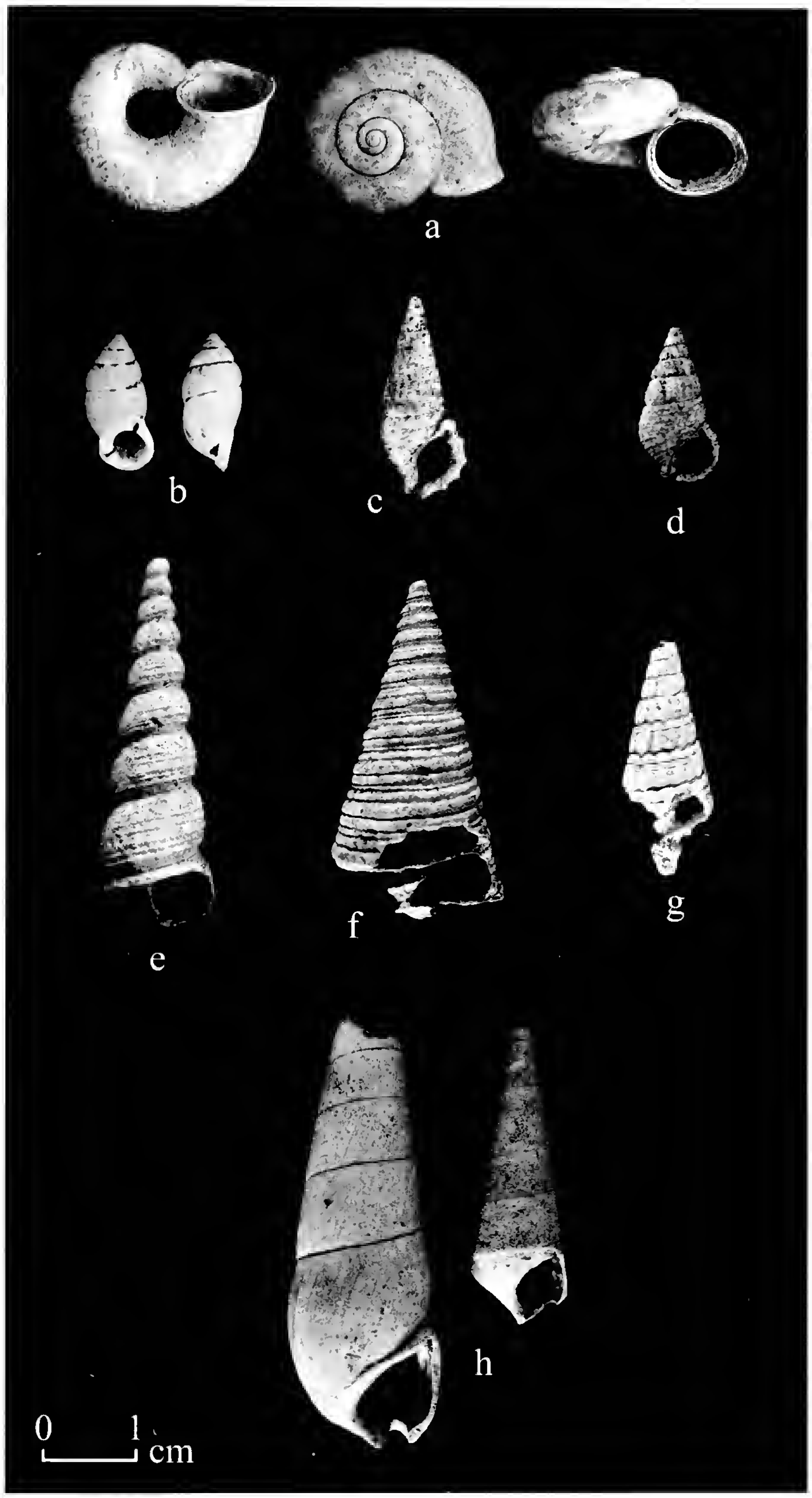

FIG. 11.3. (**a**) *Cyclotus hebraicus hebraicus*, NGRP 16/A3/A; (**b**) *Pupinella tapparonei*, 16/A2/A; (**c**) *Cerithium coralium*, 16/A1/A; (**d**) *Clypeomorus bifasciata bifasciata*, 16/A1/A; (**e**) *Turritella terebra*, 16/C3/B; (**f**) *Telescopium telescopium*, 16/A3/B; (**g**) *Terebralia palustris*, 16/B2/C; (**h**) *Faunus ater*, 23/2C/C.

estuaries on mudflats that run dry during low tide (van Benthem Jutting, 1956, p. 381; Brandt, 1974, p. 197; Houbrick, 1991a, p. 49).

Family Thiaridae

Melanoides plicarius (Born, 1780); Figure 11.4g.

Melanoides plicaria: van Benthem Jutting, 1956, p. 420, fig. 94.
Melanoides plicarius: van Benthem Jutting, 1963a, p. 480.
Melanoides (*Stenomelania*) *plicaria*: Starmühlner, 1976, p. 580, pl. 16 (182–194).

NGRP SITES—16, 23.
ECOLOGY—Lower reaches of freshwater streams, mostly in the region with tidal influence; in stagnant or very slow-moving water; on and in sandy or muddy bottom (Starmühlner, 1976, p. 586).

Melanoides punctatus (Lamarck, 1822); Figure 11.4f.

Melanoides punctata: van Benthem Jutting, 1956, p. 418, fig. 93.
Melanoides punctatus: van Benthem Jutting, 1963a, p. 471.
Melanoides (*Stenomelania*) *punctata*: Starmühlner, 1976, p. 586, pl. 17 (197–201).

NGRP SITES—16, 23.
ECOLOGY—Stagnant or slowly running freshwater, such as fish ponds and the lower reaches of streams; on or in muddy or sandy bottom (van Benthem Jutting, 1956, p. 419; Starmühlner, 1976, p. 590).
REMARKS—According to van Benthem Jutting (1963a, p. 477), the distinction between *M. punctatus* and *M. tuberculatus* can be made on the basis of the sculpture of the apical whorls, consisting of axial ribs in *M. punctatus* and predominantly spiral ridges in *M. tuberculatus*. Otherwise, both species are extremely variable and display a similarly wide range of overall shell shapes and sculptures. For instance, van Benthem Jutting (loc. cit.) reports that both species have "a tendency to develop 'shouldered' shells" in New Guinea. On the basis of examination of a large amount of material of both species, she concludes that these shouldered forms do not constitute separate taxonomic entities. It is unknown what causes the development of the shouldered shell shape. The *Melanoides* samples found here in NGRP 16 and 23 can be attributed to either *M. punctatus* or *M. tuberculatus* by their apical sculpture. However, the majority of the *Melanoides* specimens lack the apical whorls either because these eroded during the snail's lifetime or because they broke off later on. For such specimens, a decision as to whether they belong to *punctatus* or *tuberculatus* is not possible. There are also specimens with a distinct shoulder keel, specimens without any trace of a keel or shoulder, and intermediate shapes. Because of the difficulty to assign many specimens to either *M. punctatus* or *M. tuberculatus*, both species are treated together as *Melanoides punctatus/tuberculatus* in our tables and their interpretations.

Melanoides subgradatus (E. A. Smith, 1885); Figure 11.4c.

?*Melania ciliata* Brot, 1877, p. 312, pl. 32 (8).
Melania subgradata Smith, 1885, p. 601, pl. 37 (3, 3a).
Melanoides (*Stenomelania*) *subgradata*: Solem, 1953, p. 220.

NGRP SITES—16, 23.
ECOLOGY—Freshwater; "embedded in a dark calcareous loam exposed in the banks of a large stream" (Smith, 1885, p. 602).
REMARKS—The type locality of *Melania subgradata* is "large stream at Sulagina, north coast of San Cristoval," Solomon Islands. In the mollusk collection at the Museum, there are specimens from Port Torokina, Empress Augusta Bay, Bougainville, Solomon Islands (FMNH no. 146710). They agree well with our archaeological material. There are a number of additional nominal "*Melania*" species that are very close to our specimens and the recent material from Bougainville, most notably *Melania ciliata* Brot, 1877. The original figure of the latter shows the characteristic shell shape and periostracal features of that nominal taxon that are also present in the *subgradatus* specimens from Bougainville. Thus, it is possible

FIG. 11.4. (**a**) *Tarebia granifera*, NGRP 16/B1/D; (**b**) *Sermyla riquetii*, 16/C3/B; (**c**) *Melanoides subgradatus*, 16/C3/C; (**d**) *Melanoides tuberculatus*, 16/C3/D; (**e**) *Melanoides* cf. *arctecavus*, 23/2A/C; (**f**) *Melanoides punctatus*, 23/2C/C; (**g**) *Melanoides plicarius*, 16/A1/B, 23/2C/C.

that *Melania ciliata* Brot and *M. subgradata* E. A. Smith are conspecific, in which case the older name would have precedence. However, as the type locality of *M. ciliata* is unknown and no complete revision of the Thiaridae of the Indo-Pacific region has been carried out, we use here Smith's well-defined name. Neither van Benthem Jutting (1963a) nor Starmühlner (1976) mentions *M. subgradatus* from New Guinea (or from the Solomons). Thus, the subfossil specimens in the archeological material may be the first record of the species from New Guinea.

Melanoides tuberculatus (O. F. Müller, 1774); Figure 11.4d.

Melanoides tuberculata: van Benthem Jutting, 1956, p. 212, figs. 69, 73, 91.
Melanoides tuberculatus: van Benthem Jutting, 1963a, p. 473.
Melanoides tuberculata: Brandt, 1974, p. 164, pl. 12 (9–12).
Melanoides (*Melanoides*) *tuberculata*: Starmühlner, 1976, p. 591, pl. 17 (206).

NGRP SITES—16, 23.
ECOLOGY—Stagnant or slowly running freshwater, such as lakes, ponds, rice fields, trenches, rivers, brooks, and mountain creeks; occasionally in slightly brackish water; resistant to pollution; on or in mud or sand bottom (van Benthem Jutting, 1956, p. 415; Brandt, 1974, p. 166; Starmühlner, 1976, p. 594).
REMARKS—See *M. punctatus*.

Melanoides cf. ***arctecavus*** (Mousson, 1857); Figure 11.4e.

Melanoides arctecava: van Benthem Jutting, 1956, p. 425, fig. 97.

NGRP SITES—16, 23.
ECOLOGY—Freshwater or brackish water.
REMARKS—A single specimen from NGRP 23 differs from the other *Melanoides* species in the material. It resembles *M. arctecavus* from Java, as described by van Benthem Jutting (loc. cit.), in size, the almost flat whorls, coloration, and especially the shell sculpture. Our shell is, however, somewhat more slender than the specimen depicted by van Benthem Jutting. A second, somewhat broader specimen from NGRP 16 might be conspecific with the previously mentioned specimen but is badly eroded, making this assignment doubtful. According to van Benthem Jutting (1956, p. 426), *M. arctecavus* is a "problematic species" because of the sparse material of insufficient preservation represented in collections. *Melanoides arctecavus* has not been recorded from New Guinea. Because of this, the scarcity of our material, and the generally doubtful taxonomic status of *M. arctecavus*, we assign our specimen(s) to this species with some reservation.

Sermyla riquetii (Grateloup, 1840); Figure 11.4b.

Melanoides riqueti: van Benthem Jutting, 1956, p. 402, fig. 89a, b.
Melanoides riqueti: van Benthem Jutting, 1963a, p. 468.
Sermyla riqueti: Brandt 1974, p. 169, pl. 12 (19–22).

NGRP SITES—16, 23.
ECOLOGY—Freshwater and brackish water, in the lowlands (for Java, van Benthem Jutting, 1956, p. 404); brackish water or estuarine areas under tidal influence (for Thailand, Brandt, 1974, p. 169).

Tarebia granifera (Lamarck, 1822); Figure 11.4a.

Melanoides granifera: van Benthem Jutting, 1956, p. 404, fig. 90a, b.
Melanoides graniferus graniferus: van Benthem Jutting, 1963a, p. 468.
Tarebia granifera: Brandt 1974, p. 167, pl. 12 (14–18).
Tarebia granifera: Starmühlner, 1976, p. 569, pl. 16 (175–179).

NGRP SITES—16, 23.
ECOLOGY—In freshwater, either running (preferably slowly) or stagnant, such as lakes, ponds, rivers, canals, and creeks, also entering the tidal zone; on sand and mud bottom with much plant detritus; tolerant of high turbidity and pollution, water temperatures of 30–35°C and a considerable amount of salinity (van Benthem Jutting, 1956, p. 407; Brandt, 1974, p. 168; Starmühlner, 1976, p. 572).

Family Assimineidae

Dominamaria heretica van Benthem Jutting, 1963; Figure 11.5a.

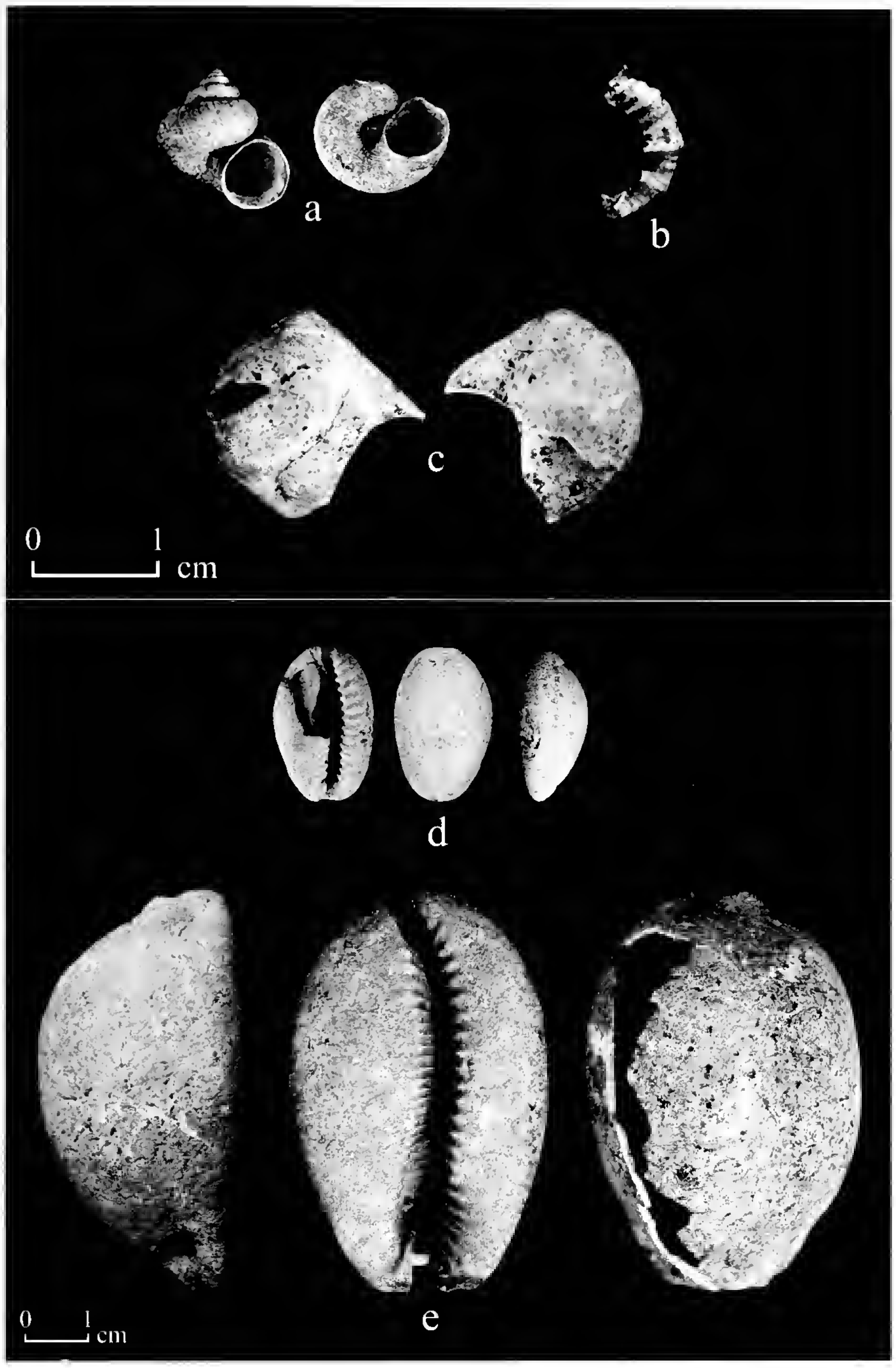

FIG. 11.5. (**a**) *Dominamaria heretica*, NGRP 16/A3/A; (**b**) *Gyrineum* cf. *bituberculare*, 46/2/2/2; (**c**) *Polinices mammilla*, 16/A3/C; (**d**) *Erosaria erosa*, 16/A1/D; (**e**) *Mauritia arabica arabica*, 16/B2/B.

Dominamaria heretica van Benthem Jutting, 1963b, p. 722, pl. 30 (40).

NGRP SITES—16, 23.
ECOLOGY—Terrestrial; the holotype and paratypes were collected along a road and in a garden (van Benthem Jutting, 1963b, p. 723); the probably closely related species *Dominamaria calvata* Wiktor, 1998, was found in leaf litter in primeval rain forest as well as in a plantation and even in mangroves (Wiktor, 1998, p. 16).

Family Hipponicidae

Cheilea sp.; Figure 11.15a.

NGRP SITE—16.
ECOLOGY—Marine; subtidal zone; sessile, permanently attached to hard substrates such as dead coral (Okutani, 2000, p. 191).

Family Cypraeidae

Erosaria annulus (Linnaeus, 1758); Figure 11.14b.

Erosaria annulus: Lorenz & Hubert, 2000, p. 204, pl. 97 (1–40), pl. 106 (17), pl. 108 (16), pl. 128 (9–11, 15).
Cypraea (*Erosaria*) annulus: Okutani, 2000, p. 239, pl. 119 (79).

NGRP SITE—16.
ECOLOGY—Intertidally, on rocky bottom, reefs, sand, and gravel (Lorenz & Hubert, 2000, p. 204; Okutani, 2000, p. 239).

Erosaria erosa (Linnaeus, 1758); Figure 11.5d.

Erosaria erosa: Lorenz & Hubert, 2000, p. 188, pl. 80 (1–22), pl. 81 (1–14), pl. 108 (9).
Cypraea (*Erosaria*) *erosa*: Okutani, 2000, p. 237, pl. 118 (70).

NGRP SITE—16.
ECOLOGY—Intertidally to about 25 m deep, on rocky bottom and reefs (Lorenz & Hubert, 2000, p. 188; Okutani, 2000, p. 237).

Mauritia arabica arabica (Linnaeus, 1758); Figure 11.5e.

Mauritia arabica arabica: Lorenz & Hubert, 2000, p. 58, pl. 12 (1, 2, 5–7), pl. 109 (7, 8).

NGRP SITES—16, 46.
ECOLOGY—Intertidally under coral slabs and stones (Lorenz & Hubert, 2000, p. 58).

Family Ovulidae

Ovula ovum (Linnaeus, 1758); Figure 11.15e.

Ovula ovum: Cernohorsky, 1971, p. 106, pl. 20 (118, 119).
Ovula ovum: Okutani, 2000, p. 219, pl. 109 (36).

NGRP SITE—16.
ECOLOGY—Marine; coral reefs, down to 20 m deep (Okutani, 2000, p. 219).

Family Naticidae

Polinices mammilla (Linnaeus, 1758); Figure 11.5c.

Polinices tumidus: Cernohorsky, 1972, p. 98, pl. 25 (10).
Polinices mammilla: Okutani, 2000, p. 253, pl. 126 (17).

NGRP SITE—16.
ECOLOGY—Marine; fine sand bottom in the subtidal zone to 20 m depth (Okutani, 2000, p. 253).

Family Ranellidae

Gyrineum cf. ***bituberculare*** (Lamarck, 1816); Figure 11.5b.

Gyrineum bituberculare: Wilson, 1993: 241, pl. 40 (7).

NGRP SITE—46.
ECOLOGY—Marine.
REMARKS—Only one aperture fragment.

Family Muricidae

Drupa morum morum Röding, 1798; Figure 11.6a.

Drupa morum: Cernohorsky 1971, p. 132, pl. 29 (176).
Drupa (*Drupa*) *morum morum*: Okutani, 2000, p. 395, pl. 196 (156).

NGRP SITES—16, 23.
ECOLOGY—Rocky bottom on reef edge (Okutani, 2000, p. 395).

Morula granulata (Duclos, 1832); Figure 11.6b.

Morula granulata: Cernohorsky, 1971, p. 134, pl. 29 (178).
Morula granulata: Okutani 2000, p. 391, pl. 194 (134).

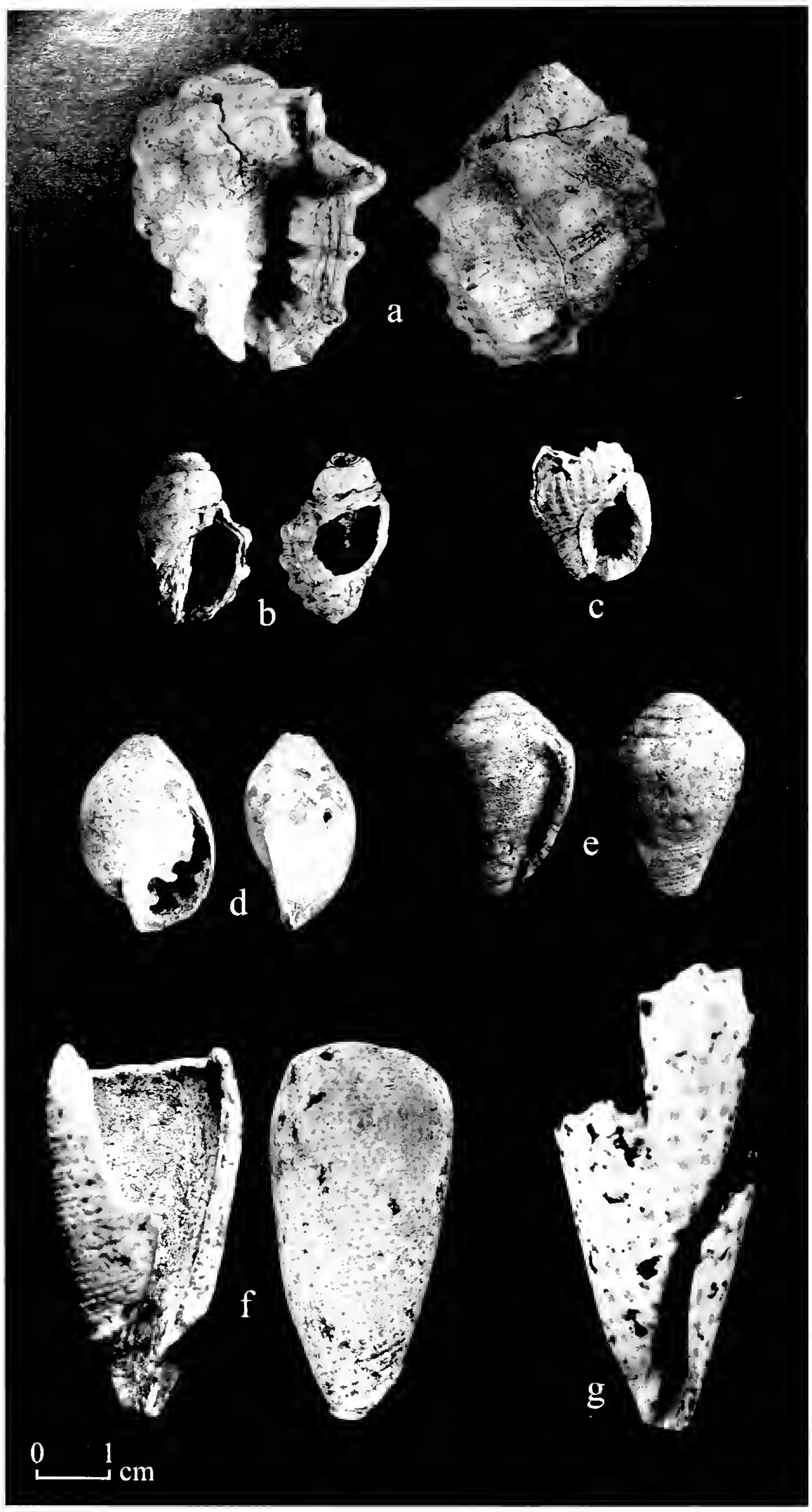

FIG. 11.6. (**a**) *Drupa morum morum*, NGRP 23/2A/B; (**b**) *Morula granulata*, 23/2A/C; (**c**) *Nassarius olivaceus*, 23/2C/C; (**d**) *Pythia scarabaeus*, 46/3/2/1; (**e**) *Conus ebraeus*, 16/A1/C; (**f**) *Conus stercusmuscarum*, 46/3/3/2; (**g**) *Conus litteratus*, 46/1A/4/2.

NGRP SITE—23.
ECOLOGY—Exposed intertidal rocky shore (Okutani, 2000, p. 391).

Family Columbellidae

Euplica turturina (Lamarck, 1822).

Pyrene (*Columbella*) *turturina*: Cernohorsky, 1972, p. 132, pl. 40 (5).
Euplica turturina: Okutani, 2000, p. 425, pl. 211 (1).

NGRP SITE—16.
ECOLOGY—On rocky bottom and in coral reefs, under boulders or dead coral slabs; intertidal zone to 20 m deep (Okutani, 2000, p. 425).

Family Nassariidae

Nassarius olivaceus (Bruguière, 1789); Figure 11.6c.

Nassarius (*Zeuxis*) *olivaceus*: Cernohorsky, 1984, p. 127, pl. 23 (9–15).
Zeuxis olivaceus: Okutani, 2000, p. 445, pl. 221 (31).

NGRP SITE—23.
ECOLOGY—Fine sand bottom in the intertidal zone to 10 m deep (Okutani, 2000, p. 445).

Family Conidae

Conus ebraeus Linnaeus, 1758; Figure 11.6e.

Conus ebraeus: Röckel et al., 1995, p. 71, pl. 8 (27–30), pl. 74 (10).
Conus (*Virroconus*) *ebraeus*: Okutani, 2000, p. 589, pl. 293 (13).

NGRP SITE—16.
ECOLOGY—On intertidal benches and subtidal coral reef platforms, to about 3 m (Röckel et al., 1995, p. 72).

Conus litteratus Linnaeus, 1758; Figure 11.6g.

Conus litteratus: Röckel et al., 1995, p. 79, pl. 10 (1–4).
Conus (*Lithoconus*) *litteratus*: Okutani, 2000, p. 587, pl. 292 (5).

NGRP SITE—46.
ECOLOGY—Marine; slightly subtidal to 50 m deep; in sand or rubble (Röckel et al., 1995, p. 79).

Conus stercusmuscarum Linnaeus, 1758; Figure 11.6f.

Conus stercusmuscarum: Röckel et al., 1995, p. 86, pl. 11 (15–18).
Conus (*Puncticulus*) *stercusmuscarum*: Okutani, 2000: 591, pl. 294 (23).

NGRP SITE—46.
ECOLOGY—Marine; intertidal and upper subtidal zones, in sand between and beneath rocks and coral (Röckel et al., 1995, p. 86; Okutani, 2000, p. 591).

Family Ellobiidae

Pythia scarabaeus (Linnaeus, 1758); Figure 11.6d.

Pythia scarabaeus: Cernohorsky, 1972, p. 212, pl. 60 (4).
Pythia pantherina: Okutani, 2000, p. 817, pl. 406 (1).

NGRP SITE—46.
ECOLOGY—Terrestrial but limited to coastal habitats; mangrove, coastal woodland (Smith, 1992, p. 219), or under litter in the splash zone (Okutani, 2000, p. 817).
REMARKS—We follow Cernohorsky (1972, p. 212) in regarding *Pythia pantherina* (A. Adams, 1851) a synonym of *P. scarabaeus*.

Family Helicarionidae

Helicarionidae.

NGRP SITE—16.
ECOLOGY—Terrestrial.
REMARKS—Shell fragments only.

Family Camaenidae

Chloritis (s.l.) sp.

NGRP SITE—16.
ECOLOGY—Terrestrial.

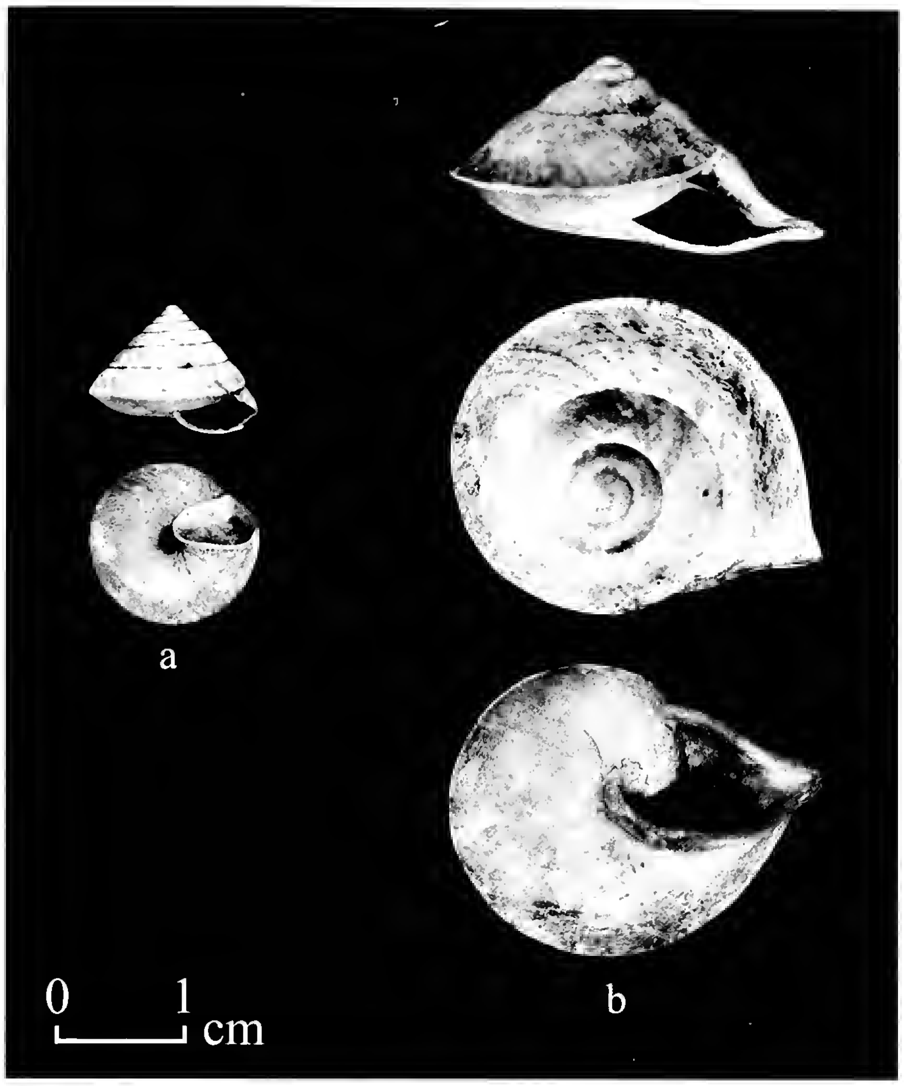

FIG. 11.7. (**a**) *Coliolus* cf. *thrix*, NGRP 23/2A/C; (**b**) *Rhynchotrochus taylorianus*, 16/A2/A.

REMARKS—Several shell fragments of a large (diameter ~4 cm) terrestrial snail with a rounded aperture that is almost not inclined, a reflected but thin peristome, and a narrow but open umbilicus that seems to belong to a large globose *Chloritis* (s.l.) species. The fragments do not allow identification to species level.

Coliolus cf. ***thrix*** Ponsonby, 1907; Figure 11.7a.

Coliolus thrix Ponsonby, 1907, p. 224.
Ganesella (*Coliolus*) *thrix*: van Benthem Jutting, 1965, 226.

NGRP SITES—16, 23.
ECOLOGY—Terrestrial.
REMARKS—The gross shape of the shells in our material resembles the original illustration given by Ponsonby (1907), and they are of about the same size. Nothing can, of course, be said about color and periostracal characters, as the periostracum is lacking in the archeological shell material. Our specimens match the original description well with respect to the shape of the aperture. However, Ponsonby describes the peristome as narrow with the columellar margin barely thickened and reflected. The Aitape specimens, on the other hand, have the peristome, in particular the basal and columellar margin, markedly expanded and the latter covers about two-fifths of the umbilicus. Also, the peristome is markedly thickened, forming a blunt protruding lip. Judging from Ponsonby's original illustration of *Coliolus thrix*, he might have had specimens before him with the aperture not quite fully developed. In *C. thrix* and closely related species such as *C. longicapillata* van Benthem Jutting, 1965, the protoconch is spirally striated. Such a striation cannot be recognized in our specimens. Presumably the striation is a feature of the periostracum.

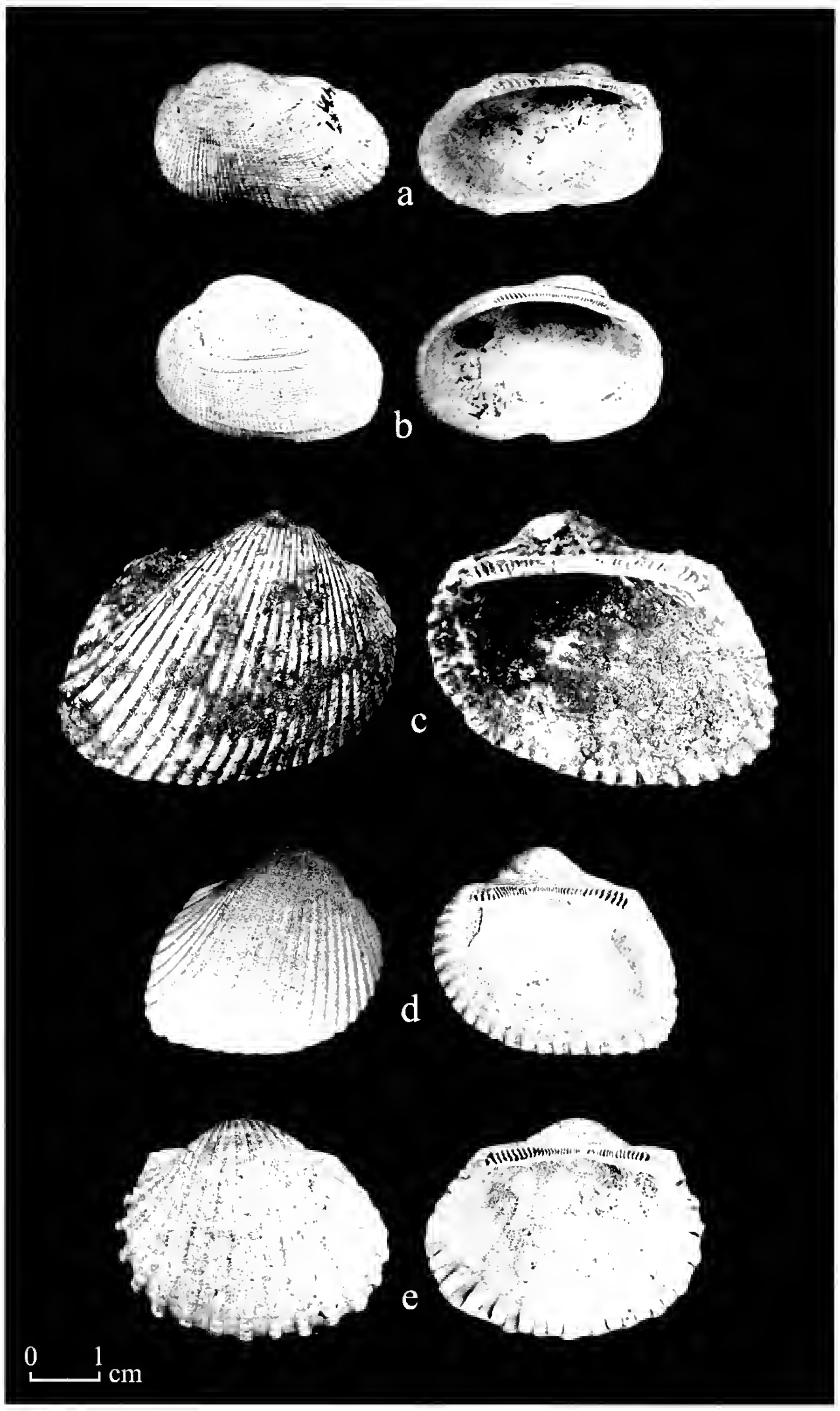

FIG. 11.8. (**a**) *Barbatia trapezina*, NGRP 46/1B/1/2; (**b**) *Barbatia fusca*, 46/1B/1/2; (**c**) *Anadara antiquata*, 46/1B/2/2; (**d**) *Anadara* sp., 16/C3/C; (**e**) *Anadara granosa*, 23/2A/C.

Papuina cf. ***honorata*** van Benthem Jutting, 1965.

Papuina (*Papuina*) *honorata* van Benthem Jutting, 1965, p. 260, pl. 7 (4).

NGRP SITE—16.
ECOLOGY—Terrestrial.
REMARKS—A single apertural fragment in our material. The shell originally had a diameter of approximately 16 mm. The last whorl is sharply keeled, the aperture broader than high, ~45° inclined, basal margin narrowly expanded and not thickened (upper half of the aperture missing), and the narrow umbilical perforation is partly covered by the reflected columellar margin of the aperture. The base is rather flattened. The very distinct sculpture of the base consists, besides having weak growth lines, of numerous, minute, somewhat irregularly spaced papillae. The fragment matches the original description and figure of *P. honorata*, especially with respect to the ornamentation with "fine, closely spaced granules" (van Benthem Jutting, 1965, p. 260). Nevertheless, because only a single fragment is available, we prefer to refer to it as *P.* cf. *honorata*.

Rhynchotrochus taylorianus (Adams & Reeve, 1850); Figure 11.7b.

Papuina (*Rhynchotrochus*) *tayloriana*: van Benthem Jutting, 1965, p. 285.

NGRP SITE—16.

ECOLOGY—Terrestrial.

Class BIVALVIA

Family Arcidae

Anadara antiquata (Linnaeus, 1758); Figure 11.8c.

Anadara (*Anadara*) *antiquata*: Evseev & Lutaenko, 1998, p. 8, pl. 1 (J).

Anadara (*Anadara*) *antiquata*: Lamprell & Healy, 1998, p. 52, fig. 76.

Anadara antiquata: Okutani, 2000, p. 853, pl. 424 (35).

NGRP SITES—16, 46.

ECOLOGY—Silty sand bottoms in the upper subtidal zone, also attached by byssus to coral fragments on coarse sand (Evseev & Lutaenko, 1998, p. 9); sandy mud bottom with shell fragments in lower intertidal zone to 5 m deep (Okutani, 2000, p. 853).

Anadara granosa (Linnaeus, 1758); Figures 11.8e and 11.14e.

Anadara (*Tegillarca*) *granosa*: Evseev & Lutaenko, 1998, p. 22, pl. 3 (D).

Anadara (*Tegillarca*) *granosa*: Lamprell & Healy, 1998, p. 54, fig. 78.

Tegillarca granosa: Okutani, 2000, p. 855, pl. 425 (45).

NGRP SITES—16, 23, 35, 46.

ECOLOGY—Muddy bottoms of embayments influenced by nonmarine waters, intertidal zone to 10 m deep (Evseev & Lutaenko, 1998, p. 22; Okutani, 2000, p. 855).

Anadara sp.; Figure 11.8d.

?*Anadara* (*Scapharca*) sp. 1: Evseev & Lutaenko, 1998, p. 32, pl. 1 (G).

NGRP SITES—16, 23.

ECOLOGY—Marine.

REMARKS—Two specimens, one left and one right valve from different samples, resemble Enseev & Lutaenko's "*Anadara* (*Scapharca*) sp. 1."

Barbatia fusca (Bruguière, 1789); Figure 11.8b.

Barbatia (*Barbatia*) *amygdalumtostum*: Lamprell & Healy, 1998, pp. 48, 49, fig. 60.

Barbatia (*Ustularca*) *fusca*: Okutani, 2000, p. 847, pl. 421 (9).

Barbatia (*Barbatia*) *amygdalumtostum*: Swennen et al., 2001, p. 64, plate fig. 022.

Barbatia fusca: Agüera García & Oliver, 2008, p. 15, figs. 5e, 6i, j, 9a, b.

NGRP SITES—16, 46.

ECOLOGY—Marine; attached by byssus to rocks or coral in the upper subtidal zone of littoral and coral reef areas (Lamprell & Healy, 1998, p. 48; Okutani 2000, p. 847).

Barbatia trapezina (Lamarck, 1819); Figure 11.8a.

Barbatia (*Barbatia*) *trapezina*: Lamprell & Healy, 1998, p. 46, fig. 57.

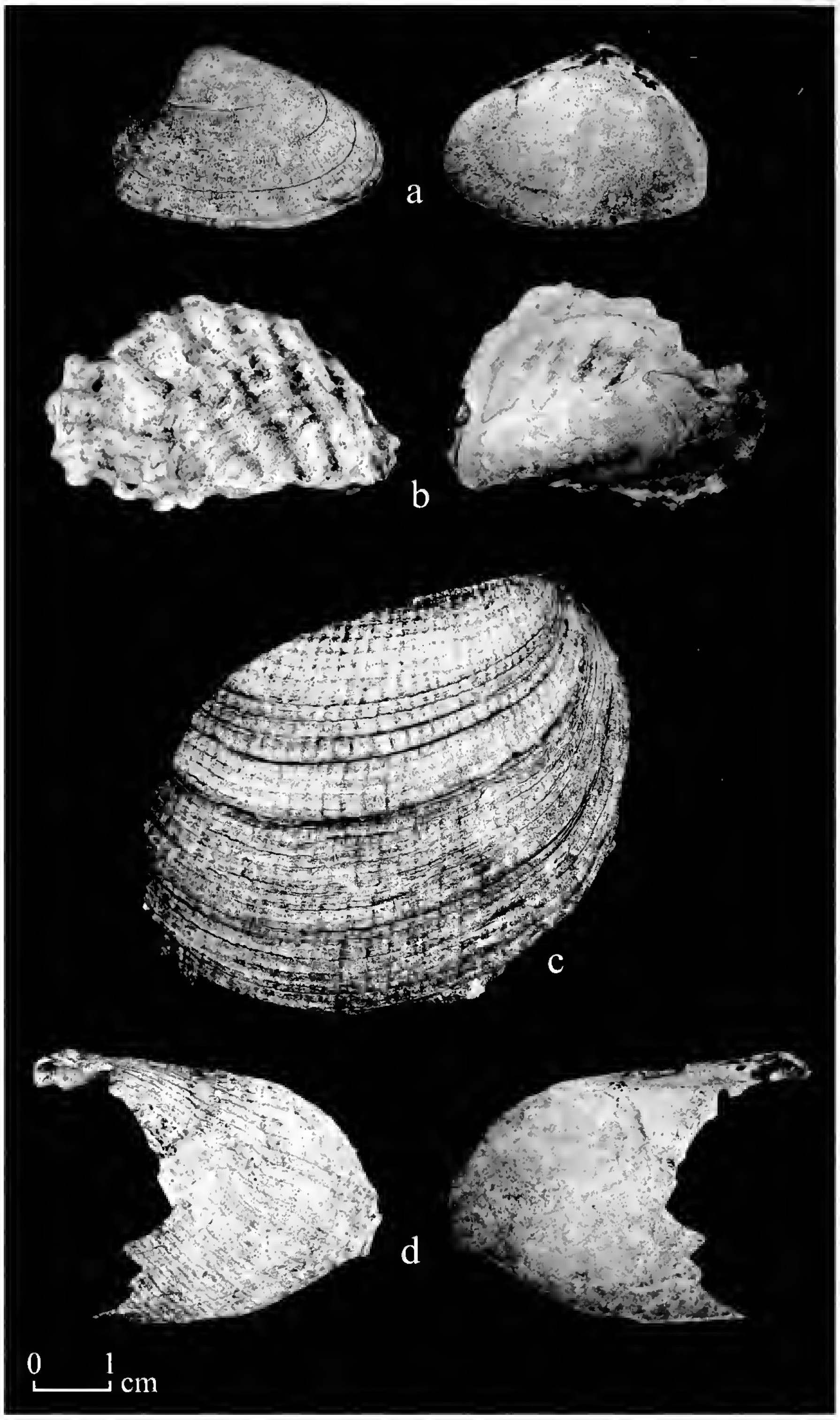

FIG. 11.9. (**a**) *Donax cuneatus*, 23/2A/C; (**b**) Ostreidae, 23/2E/C; (**c**) *Codakia tigerina*, 46/3/1/1; (**d**) *Asaphis violascens*, 16/B3/B.

Barbatia (*Abarbatia*) *lima*: Okutani, 2000, p. 847, pl. 421 (5).

Barbatia trapezina: Agüera García & Oliver, 2008, p. 10, figs. 2a–f, 4b, 5b, 6e, f, 7c.

NGRP SITE—46.

ECOLOGY—Marine; attached by byssus to rock, corals, or debris from the intertidal zone to 20 m deep (Lamprell & Healy, 1998, p. 46; Okutani, 2000, p. 847).

Family Ostreidae

Ostreidae Figure 11.9b.

NGRP SITES—16, 23, 35.

ECOLOGY—Marine; sessile, attached to hard substrates.

REMARKS—Among the fragmentary oyster shells in the material are shells likely belonging to the genus *Saccostrea*, such as *Saccostrea mordax* (Gould, 1850), a common species on hard substrates of tropical Indo-West Pacific coasts and abundant on mangrove roots (Itoigawa et al., 2003, p. 93, pl. 6 [1]). However, there are probably fragments of other oyster taxa in the material as well.

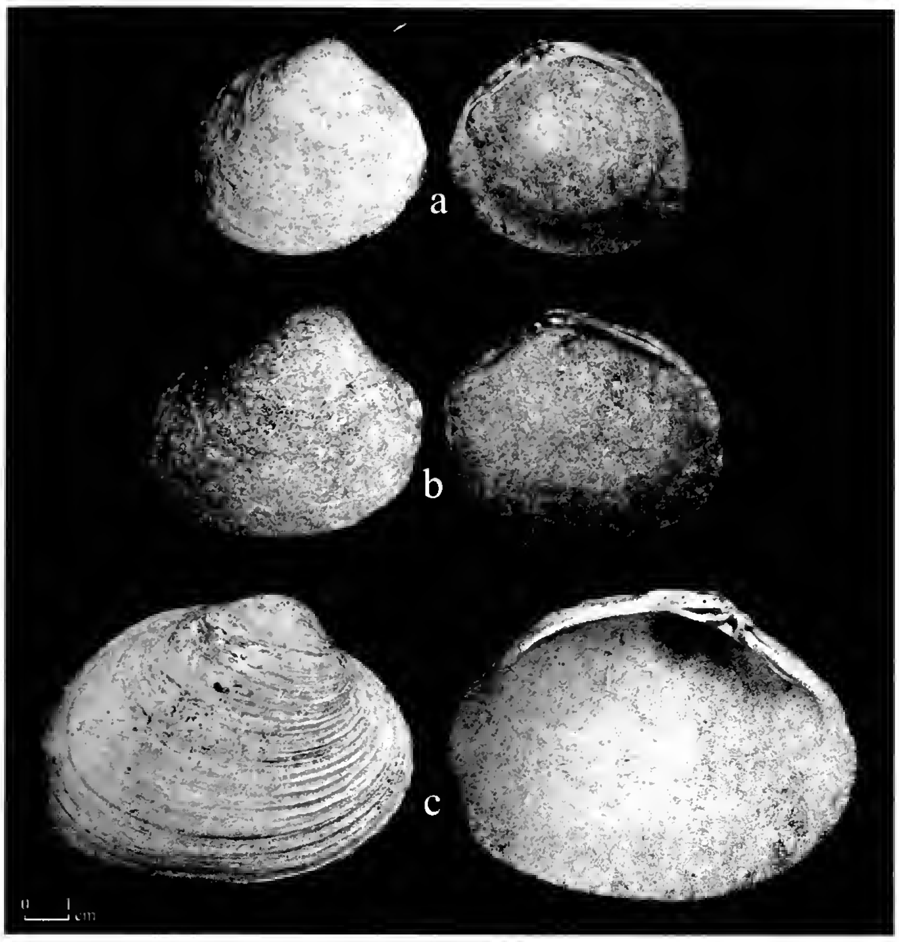

FIG. 11.10. (**a**) *Batissa albertisii albertisii*, 23/2B/C; (**b**) *Batissa subtrigona*, 16/B3/B; (**c**) *Batissa violacea*, 23/2C/C, 23/2C/C1.

Family Placunidae

Placuna ephippium (Philipsson in Retzius, 1788); Figure 11.14a.

Placuna (*Ephippium*) *ephippium*: Lamprell & Whitehead, 1992, no. 88, pl. 15 (88).
Placuna ephippium: Swennen et al., 2001, p. 76, fig. 079.

NGRP SITE—16.
ECOLOGY—Marine; free living (i.e., not attached to the substrate by byssus or cementation) on fine sediments (Swennen et al., 2001, p. 76); on surface of mud near mangroves (Lamprell & Whitehead, 1992, no. 88, pl. 15 [88]).
REMARKS—Three shell pieces of 23–30 mm in largest extension were recovered (Fig. 11.14a). They seem to be broken out of the large (up to 20 cm) shells of *Placuna ephippium* and worked into somewhat round, thin disks. The smallest disk shows remnants of the characteristic fine radial sculpture of *Placuna*, and all three disks show in part dark coloration as in *P. ephippium*. Therefore, although the disks were obviously made from a much larger shell and do not show any characteristics of the shell shape, we regard it safe to assign the disks to *P. ephippium*.

Family Lucinidae

Codakia tigerina (Linnaeus, 1758); Figure 11.9c.

Codakia tigerina: Cernohorsky, 1972, p. 221, pl. 62 (3).

NGRP SITE—46.
ECOLOGY—Marine; in coral sand in the intertidal zone (Cernohorsky, 1972, p. 221).

Family Psammobiidae

Asaphis violascens (Forsskål, 1775); Figure 11.9d.

Asaphis violascens: Cernohorsky, 1972, p. 231, pl. 66 (7).
Asaphis (*Asaphis*) *violascens*: Lamprell & Whitehead, 1992, pl. 54 (405).
Asaphis violascens: Okutani, 2000, p. 987, pl. 491 (15).

NGRP SITE—16.
ECOLOGY—Marine; sand bottom with gravel in intertidal zone (Okutani, 2000, p. 987).

Family Donacidae

Donax cuneatus Linnaeus, 1758; Figure 11.9a.

Donax (*Latona*) *cuneatus*: Cernohorsky, 1978, p. 185, pl. 67 (5).
Donax (*Latona*) *cuneatus*: Lamprell & Whitehead, 1992, pl. 51 (379).
Latona cuneata: Okutani, 2000, p. 971, pl. 483 (2).

NGRP SITES—16, 23, 46.
ECOLOGY—Marine; sand bottom of upper intertidal zone (Okutani, 2000, p. 971).

Family Corbiculidae

Batissa albertisii albertisii Tapparone Canefri, 1883; Figure 11.10a.

Batissa albertisii Tapparone Canefri, 1883, p. 289, pl. 11 (1).

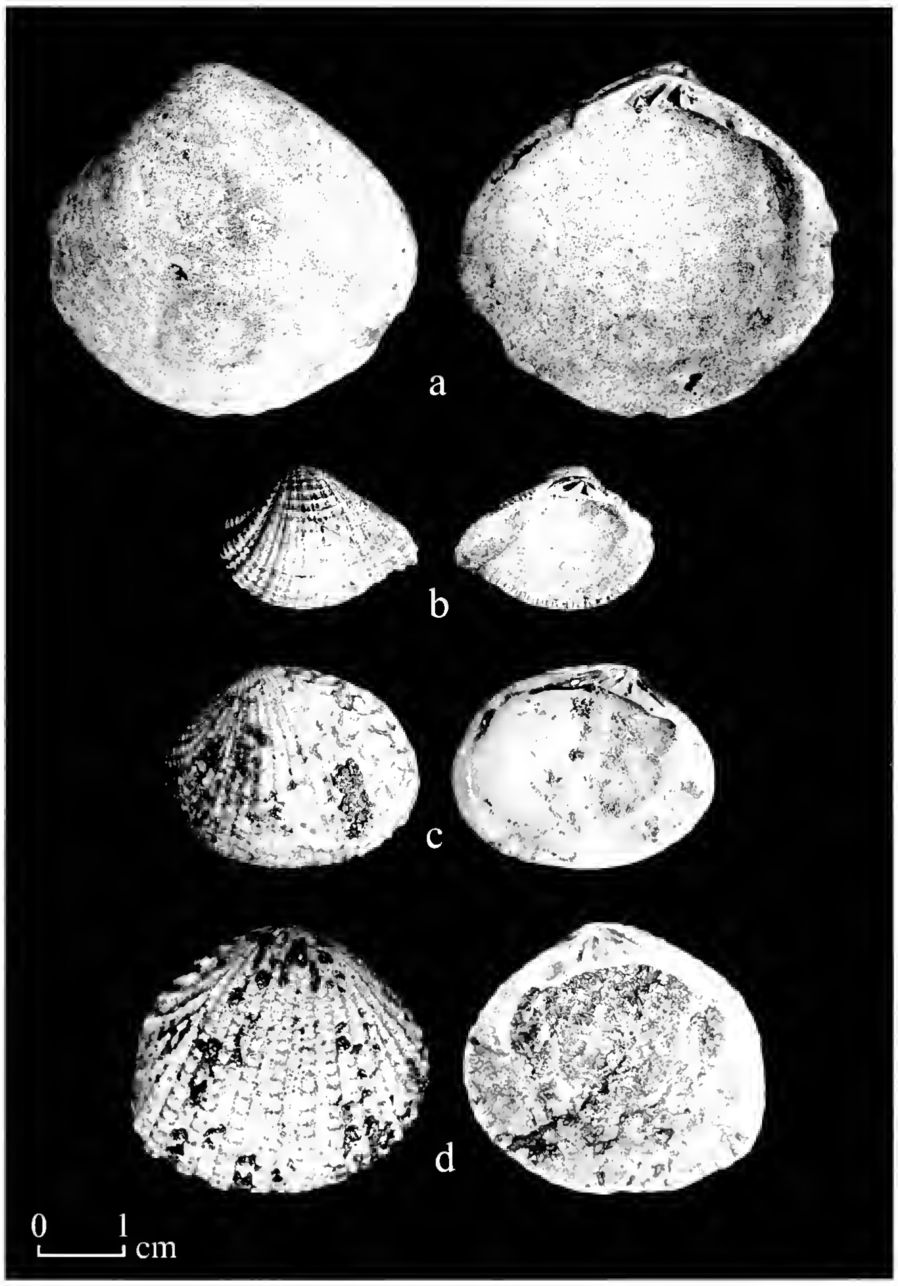

FIG. 11.11. (**a**) *Geloina erosa*, 23/2C/C; (**b**) *Anomalocardia squamosa*, 23/2C/C; (**c**) *Gafrarium pectinatum*, 46/2/2/2; (**d**) *Gafrarium tumidum*, 46/1B/2/2.

Batissa albertisii albertisii: van Benthem Jutting, 1963a, p. 510.

NGRP SITES—16, 23, 46.
ECOLOGY—Freshwater; rivers (Tapparone Canefri, 1883, p. 289; van Benthem Jutting, 1963a, p. 510).
REMARKS—Riech (1937, p. 87) argues that *B. albertisii*, *B. subtrigona*, and some other nominal species of *Batissa* are merely ecophenotypic variations of the widespread *B. violacea*. Likewise, Morton (1984, p. 77) assumes that "a single species of ... *Batissa* (i.e., *B. violacea* ...) ... occurs in the Indo-Pacific." However, van Benthem Jutting (1963a, p. 510 ff.) maintains that there are several distinct species in New Guinea. In the absence of a thorough revision of the genus, we follow van Benthem Jutting and assign our material to three morphospecies.

Batissa subtrigona Thiele, 1928; Figure 11.10b.

Batissa subtrigona Thiele, 1928, p. 144.
Batissa subtrigona: van Benthem Jutting, 1963a, p. 511.

NGRP SITES—16, 23.
ECOLOGY—Freshwater; rivers (Thiele, 1928, p. 144; van Benthem Jutting, 1963a, p. 511).
REMARKS—See *B. albertisii albertisii.*

Batissa violacea (Lamarck, 1818); Figure 11.10c.

Batissa violacea: van Benthem Jutting, 1963a, p. 511.
Batissa violacea: Lamprell & Healy, 1998, p. 182.

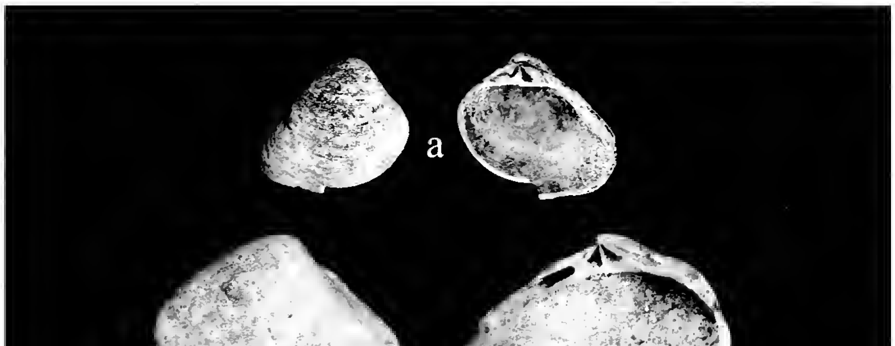

FIG. 11.12. (**a**) Cf. *Lioconcha* sp., 23/2C/B; (**b**) *Meretrix meretrix*, 23/2A/B; (**c**) *Periglypta reticulata*, 46/1B/2/2; (**d**) *Periglypta puerpera*, 46/3/2/5.

NGRP SITES—16, 23.
ECOLOGY—Fresh and brackish water; coastal rivers, streams and estuaries (Lamprell & Healy, 1998, p. 182).
REMARKS—See *B. albertisii albertisii.* According to van Benthem Jutting (1963a, p. 512), *B. violacea* is a favorite food for the local populations in the islands of Misool and Monod de Froideville off the coast of New Guinea.

Geloina erosa (Solander, 1786); Figure 11.11a.

Cyrena viridescens: Tapparone Canefri, 1883, p. 285, pl. 10 (24).
Polymesoda viridescens: van Benthem Jutting, 1963a, p. 509.
Polymesoda (*Geloina*) *erosa*: Morton, 1984, p. 77 ff., pl. 3 (B), pl. 4 (B).

NGRP SITES—16, 23, 46.
ECOLOGY—Estuarine/brackish water/mangrove; brackish water in the estuarine area of rivers and mangroves (Tapparone Canefri, 1883, p. 286; Brandt, 1974, p. 308; Morton, 1984, p. 77 ff.).

Family Cardiidae

Tridacna sp.; Figure 11.14c, d.

NGRP SITE—46.
ECOLOGY—Marine; in coral reef environments, intertidal to upper subtidal zones (Okutani, 2000, pp. 959–961).
REMARKS—A disk and a ring fragment manufactured from the unusually thick shells of *Tridacna* sp. were recovered on Tumleo (Fig. 11.14c, d).

Family Veneridae

Anomalocardia squamosa (Linnaeus, 1758); Figure 11.11b.

Anomalodiscus squamosus: Fischer-Piette & Vukadinovic, 1977, p. 51.
Anomalocardia (*Anomalodiscus*) *squamosa*: Lamprell & Whitehead, 1992, pl. 61 (465).
Anomalocardia squamosa: Okutani, 2000, p. 1003, pl. 499 (7).

NGRP SITES—16, 23.
ECOLOGY—Marine; mud bottom in intertidal zone of embayments (Okutani, 2000, p. 1003).

Gafrarium pectinatum (Linnaeus, 1758); Figure 11.11c.

Gafrarium pectinatum: Cernohorsky, 1972, p. 234, pl. 67 (1).
Gafrarium pectinatum: Lamprell & Whitehead, 1992, pl. 66 (506).
Gafrarium pectinatum: Okutani, 2000, p. 1007, pl. 501 (24).

NGRP SITE—46.
ECOLOGY—Marine; coarse sand bottom in middle intertidal zone to 20 m deep (Okutani, 2000, p. 1007).

Gafrarium tumidum (Röding, 1798); Figure 11.11d.

Gafrarium tumidum: Cernohorsky, 1972, p. 234, pl. 67 (2).
Gafrarium tumidum: Lamprell & Whitehead, 1992, pl. 65 (501).
Gafrarium tumidum: Okutani, 2000, p. 1007, pl. 501 (22).

NGRP SITE—46.
ECOLOGY—Marine; coarse sand bottom in middle intertidal zone to 20 m deep (Okutani, 2000, p. 1007).

cf. ***Lioconcha*** sp.; Figure 11.12a.

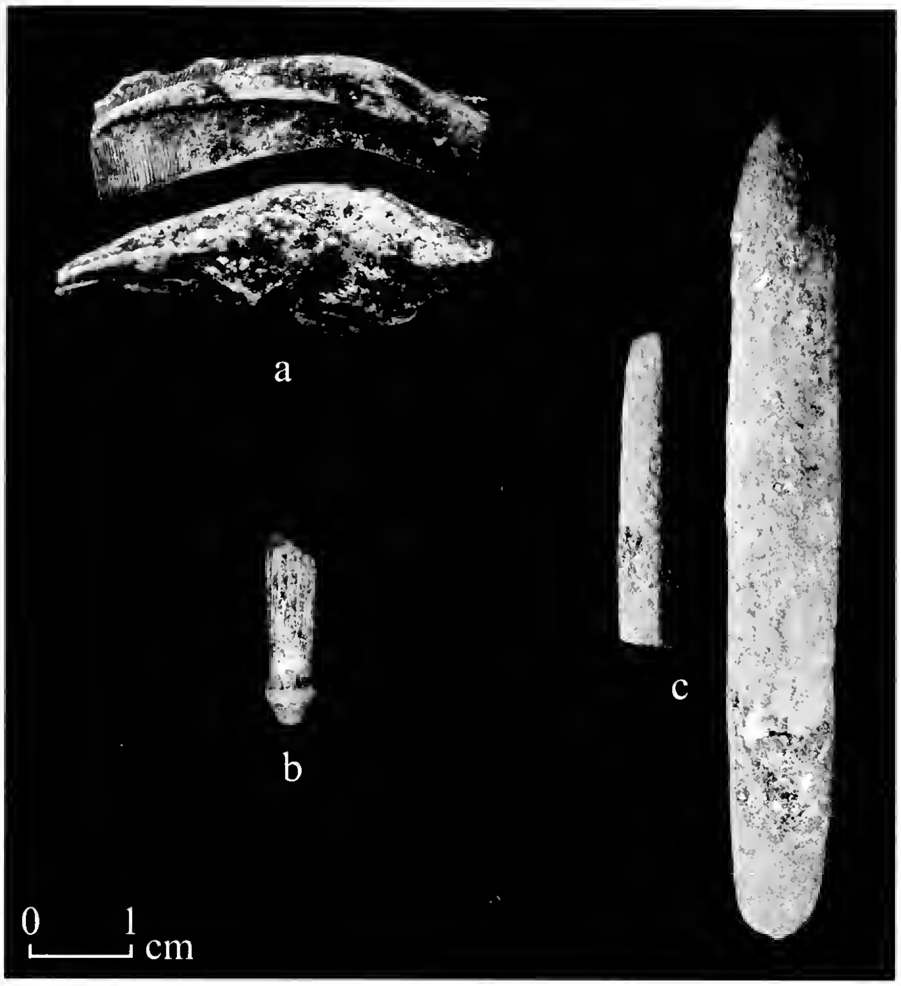

FIG. 11.13. (**a**) Cirripedia, plates, 46/1-2C/1/2; (**b**) Cidaridae, spine, 23/2E/C; (**c**) *Heterocentrotus mammillatus*, spines, 46/2/2/5.

NGRP SITE—23.
ECOLOGY—Marine.

Meretrix meretrix (Linnaeus, 1758); Figure 11.12b.

Meretrix meretrix: Bernard et al., 1993, p. 86.

NGRP SITE—23.
ECOLOGY—Marine; intertidal zone to 20 m in sand and mud (Bernard et al., 1993, p. 86).

Periglypta puerpera (Linnaeus, 1771); Figure 11.12d.

Periglypta puerpera: Cernohorsky, 1972, p. 233, pl. 66 (5).
Antigona (*Periglypta*) *puerpera*: Lamprell & Whitehead, 1992, pl. 60 (457).
Periglypta puerpera: Okutani, 2000, p. 1003, pl. 499 (5).

NGRP SITE—46.
ECOLOGY—Marine; sand bottom in lower intertidal zone to 20 m deep (Okutani, 2000, p. 1003).

Periglypta reticulata (Linnaeus, 1758); Figure 11.12c.

Periglypta reticulata: Cernohorsky, 1972, p. 233, pl. 66 (6).
Antigona (*Periglypta*) *reticulata*: Lamprell & Whitehead, 1992, pl. 60 (459).
Periglypta reticulata: Okutani, 2000, p. 1003, pl. 499 (4).

NGRP SITE—46.
ECOLOGY—Marine; sandy gravel bottom in lower intertidal zone to 20 m deep (Okutani, 2000, p. 1003).

Phylum ARTHROPODA

Class CRUSTACEA

Cirripedia Figure 11.13a.

NGRP SITE—46.
ECOLOGY—Marine; sessile, cemented to hard substrates.
REMARKS—Fragments of a large barnacle species.

Phylum ECHINODERMATA

Class ECHINOIDEA

Family Cidaridae

Cidaridae Figure 11.13b.

NGRP SITE—23.
ECOLOGY—Marine; mostly on reefs but also found on other hard substrates (Mortensen, 1943).
REMARKS—Basal half of one spine.

Family Echinometridae

Heterocentrotus mammillatus (Linnaeus, 1758); Figure 11.13c.

Heterocentrotus mammillatus: Mortensen, 1943, p. 409, pl. 51 (1–6), pl. 52 (6–8), pl. 66 (7, 9–20).

NGRP SITE—46.
ECOLOGY—Marine; mostly on reefs but also found on other hard substrates (Mortensen, 1943).
REMARKS—One large, whole spine and one broken-off distal part of a smaller spine.

Interpretation of the Faunal Assemblages

In total, remains of at least 75 invertebrate species have been recovered (72 Mollusca, one Arthropoda, two Echinodermata). Of these, 45 taxa are marine, 19 are from freshwater, estuarine, and mangrove habitats, and 11 are terrestrial.

Mainland Excavations (NGRP 16 and 23)

At both sites in the Aitape hills, the overwhelming majority of the recovered molluscan shells (77% for both sites combined) belongs to species inhabiting freshwater, brackish water, or mangrove habitats (Tables 11.1 and 11.2). As there are no suitable aquatic habitats in the hills themselves and there have not been in the past several thousand years, these mollusks must have been brought up from aquatic habitats in the lowlands adjacent to the hills. Presumably, these mollusks were gathered primarily as food items. The F/B/M shells are frequently fragmentary in ways suggesting that they were broken in order to extract the meat. In *Melanoides* spp. and *Faunus ater*, the breakage patterns include damaged apertures as well as shells broken into two or several pieces. In *Neritina* spp. and *Neritodryas* spp., the dorsum of the shell is frequently broken off. In *Batissa* spp. and *Geloina erosa*, we observed damage to the margins of shells, as if the two valves of a clam had been pried open, as well as completely shattered shells.

Although the marine species found display the greatest diversity (29 species as opposed to 19 F/B/M and 10 terrestrial), all species, with one exception, occur in small numbers, often as unique examples. *Anadara granosa* is the only marine species occurring in some abundance and may thus have played a role as a food item. On the whole, marine shellfish species seem not to have been utilized as food to a significant degree in the Aitape hills.

TABLE 11.1. Invertebrate remains recovered at site NGRP 16.

Site NGRP 16	A1/ A	A1/ B	A1/ C	A1/ D	A2/ A	A2/ B	A2/ C	A2/ D	A3/ A	A3/ B	A3/ C	A3/ D	B-C1- 3/A	B1/ B	B1/ C	B1/ D	B2/ B	B2/ C	B2/ D	B3/ B	B3/ C	C1/ B	C1/ C	C2/ B	C2/ C	C2/ D	C3/ B	C3/ C	C3/ D	Probe #1	Site total
Marine																															
Anadara antiquata																								1					1		**2**
Anadara granosa			1														1						2	1	1				1		**7**
Anadara sp.						0					0					1			0									1			**2**
Anomalocardia squamosa				1							1																				**2**
Asaphis violascens																				1											**1**
Barbatia fusca																											1				**1**
Cheilea sp.																												1			**1**
Clypeomorus bifasciata bifasciata	1					1			1																						**3**
Conus ebraeus			1																												**1**
Conus sp.													1																		**1**
Donax cuneatus	2	1			1	1			1		1		1				1	1	1									1	1		**13**
Drupa morum morum																											1				**1**
Erosaria annulus																		1													**1**
Erosaria erosa				1															1												**2**
Euplica turturina																	1														**1**
Mauritia arabica arabica																	1														**1**
Nerita rumphii																				1											**1**
Ostreidae			1																										1		**2**
Ovula ovum							1										1														**2**
Placuna ephippium												1																			**1**
Polinices mammilla											1																				**1**
Polyplacophora																													1		**1**
Tectus niloticus												1																			**1**
Trochus sp.		1																	1					1							**3**
Turbo chrysostomus																									1						**1**
Turbo cf. *petholatus*															1																**1**
Turritella terebra																								1			1				**2**
Subtotal (marine)	**3**	**2**	**3**	**2**	**1**	**2**	**1**	**0**	**2**	**0**	**3**	**2**	**2**	**0**	**1**	**1**	**5**	**2**	**3**	**2**	**0**	**0**	**2**	**4**	**2**	**0**	**3**	**3**	**5**	**0**	**56**
Freshwater/brackish water/mangrove																															
Batissa albertisii albertisii																								1				1			**2**
Batissa sp.		6	1		1	0	8		1	3	4		1		1		0								2		1		0		**29**
Batissa subtrigona																	0			1											**1**
Batissa violacea		0				3	11														2										**16**
Cerithium coralium	1																														**1**
Faunus ater	1	1			1												2				1						3	3			**12**
Geloina erosa	1	2					1								1		1										2		1		**9**
Batissa/Geloina—fragments	2	0	1	1	1	0	16			1	0	1	1		1	1	3	1	1	1	1	1		1	1	1	2	2	1	1	**43**
Melanoides—fragments																				0									1	1	**2**
Melanoides plicarius		7	3										2		1	2		1	1	3					3			2	1		**26**
Melanoides punctatus/tuberculatus	23	117	40	10	9	29	3		10	10	12	10	2	14	12	7	41	24	6	36	15	3	1	24	55	3	19	38	67	1	**641**
Melanoides sp.	1																						2	2							**5**
Melanoides subgradatus		3	4	2		4		1			2		1	2	6	1	10	6	1	9	2			16	42	2	12	28	48		**202**
Neritina pulligera	2				3	1	4				1	1	1				3			1	2		1	7	2	1	2		1	5	**38**
Neritina waigiensis	31	26	7	1	8	7		1	3		3		1				5			2		5	1	6	2		2	2		2	**115**
Neritina/Neritodryas—fragments																											0		2		**2**
Neritodryas cornea	19	2	2	1	1			1		2	1						1			4				1		1		4			**40**
Neritodryas subsulcata	1									1			1												1					1	**5**
Sermyla riquetii																											1				**1**
Tarebia granifera		1	3	1	1	1					1			1		2	2								1						**14**

Table 11.1. *Continued.*

Site NGRP 16	A1/ A	A1/ B	A1/ C	A1/ D	A2/ A	A2/ B	A2/ C	A2/ D	A3/ A	A3/ B	A3/ C	A3/ D	B-C1- 3/A	B1/ B	B1/ C	B1/ D	B2/ B	B2/ C	B2/ D	B3/ B	B3/ C	C1/ B	C1/ C	C2/ B	C2/ C	C2/ D	C3/ B	C3/ C	C3/ D	Probe #1	Site total
Telescopium telescopium										1					1																**2**
Terebralia palustris																		1													**1**
Subtotal (F/B/M)	**82**	**165**	**61**	**16**	**25**	**45**	**43**	**3**	**14**	**18**	**24**	**12**	**10**	**17**	**23**	**13**	**68**	**33**	**9**	**57**	**23**	**9**	**5**	**58**	**109**	**8**	**44**	**80**	**122**	**11**	**1207**
Terrestrial																															
Chloritis (s.l.) sp.		1				1			1		1																				**4**
Coliolus cf. *thrix*					6				1																				1		**8**
Cyclotus hebraicus hebraicus	3	1	3		5	2			10	3	4	1			2		3	3		3	2		1	2	2		2	1	1		**54**
Diplommatina sp.																					1										**1**
Dominamaria heretica	11	29	1	2	17	15			22	7	3				2	2	3			9		1		6	1		6		1	1	**139**
Helicarionidae					1																										**1**
Lagochilus sp.					1	1																									**2**
Papuina cf. *honorata*									1																						**1**
Pupinella tapparonei	4	1		1	9	2			3		1	2															1				**24**
Rhynchotrochus taylorianus	1	1			2																										**4**
Subtotal (terrestrial)	**19**	**33**	**4**	**3**	**41**	**21**	**0**	**0**	**38**	**10**	**9**	**3**	**0**	**0**	**4**	**2**	**6**	**3**	**0**	**12**	**3**	**1**	**1**	**8**	**3**	**0**	**9**	**1**	**3**	**1**	**238**
Total	**104**	**200**	**68**	**21**	**67**	**68**	**44**	**3**	**54**	**28**	**36**	**17**	**12**	**17**	**28**	**16**	**79**	**38**	**12**	**71**	**26**	**10**	**8**	**70**	**114**	**8**	**56**	**84**	**130**	**12**	**1501**

Terrestrial snail shells are concentrated at the surface and in the uppermost soil layers. Here they represent the remains of snails that lived in situ in the recent past. This assumption is backed by the fact that some specimens still have color as well as remnants of the periostracum, the thin, proteinaceous, outer layer of the shell. The lower numbers of terrestrial shells at deeper levels can be explained by the thinner shell and smaller size of many of the terrestrial species compared with the freshwater and especially the marine species, making them more vulnerable to mechanical and chemical destruction. Only three land snail species occur in significant numbers: *Cyclotus hebraicus hebraicus* (107 specimens at NGRP 16 and 23 combined), *Dominamaria heretica* (199 specimens) and *Pupinella tapparonei* (26 specimens). With an adult size of ~1 cm, the latter two are unlikely to be attractive as food items (*C. h. hebraicus* measures between 2 and 3 cm). Furthermore, no breakage patterns pointing in the direction of human consumption, as seen in the common F/B/M species, have been observed in the common land snails. We conclude, therefore, that terrestrial snails played no significant role in human nutrition.

Tumleo Island Excavations (NGRP 46)

Representative specimens of readily discernable species of shells from the excavations on Tumleo Island were brought to the Museum for identification (Table 11.3). Nearly all identifiable species from NGRP 46 are marine. One exception is the sole specimen of *Pythia scarabaeus*, which, although it has a terrestrial lifestyle, is restricted to habitats in the immediate vicinity of the sea, such as mangrove swamps and beaches. The only freshwater/brackish water mollusks found are *Faunus ater*, *Batissa* spp., and *Geloina erosa*, three taxa known to occur in estuarine environments, at the interface of freshwater and salt water (van Benthem Jutting, 1956, p. 381; Brandt, 1974, p. 197; Houbrick, 1991b, p. 49). All other F/B/M species found at the hill sites, NGRP 16 and 23, are absent at NGRP 46. Although no observations concerning the current molluscan fauna of Tumleo have been made, it is unlikely that the small coral island, situated ~3 km offshore has or ever had suitable freshwater or brackish water habitats for the three F/B/M species recovered from the excavations on the island. Therefore, it is likely that these species have been brought in from coastal estuarine and mangrove areas of the mainland.

Examination of the stratigraphic excavations made on Tumleo Island shows that marine and F/B/M specimens were found in all layers except for the lowest layers of test pit 2 (2/2/3–2/2/5—no F/B/M species) as well as two units in test pit 3 (3/2/2—no marine; 3/2/5—no F/B/M). The absences in the latter two layers may be statistical since comparatively little material was found in either layer. However, the absence of F/B/M species at the bottom of test pit 2 in layers associated with Nyapin Ware (Chapter 7), the only Nyapin layers found during excavation, may be significant. Perhaps people on Tumleo Island at that time did not have access to these mainland species either directly or through friendship (exchange) relationships.

Breakage patterns in the three F/B/M species from Tumleo are similar to the F/B/M species at NGRP 16 and 23 (see above). It is therefore probable that they were food resources. Likewise, some of the marine shells recovered at NGRP 46 show breakage patterns consistent with human consumption. For instance, a large shell fragment of the marine gastropod *Conus litteratus* shows a breakage pattern typical for snails of

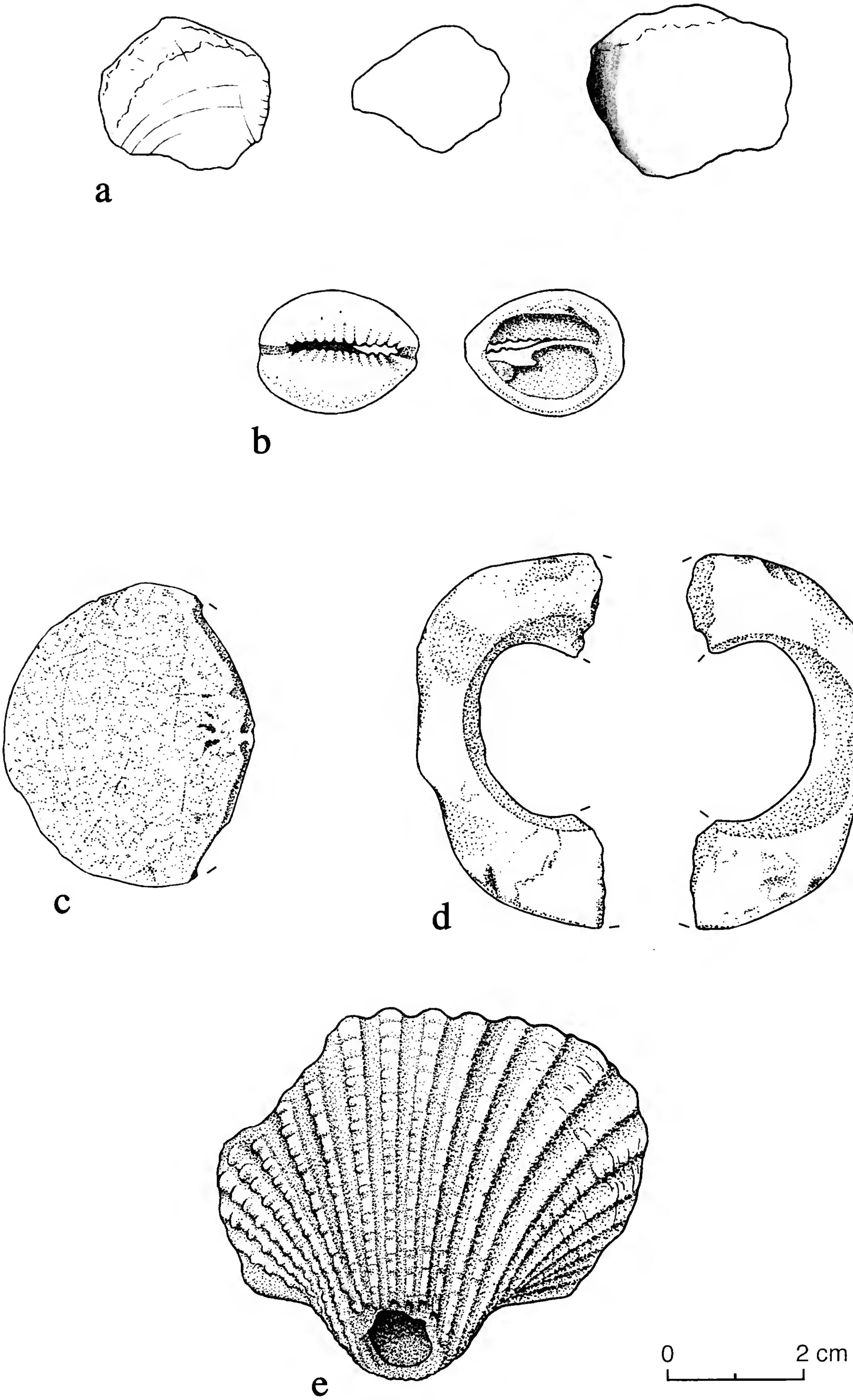

FIG. 11.14. Shell artifacts: (**a**) *Placuna ephippium*, ornament, NGRP 16/A3/D; (**b**) *Erosaria annulus*, ornament, 16/B2/C; (**c**) *Tridacna* sp., shell disc, 46/3/1/1; (**d**) *Tridacna* sp., shell ring (half), 46/1B/1/1; (**e**) *Anadara granosa*, net sinker, 46/3/3/1.

Table 11.2. Invertebrate remains recovered at site NGRP 23.

Site NGRP 23	East slope near top	Probe 1	Surface north side of hill	A2/ A	A2/ B	A2/ C1	A2/ C2	B2/ B	B2/ C1	B2/ C2	B2/D (top)	C2/ surface	C2/ B	C2/ C	C2/ C1	C2/ C2	D2/ surface	D2/ B	D2/ C2	D2/ A or B2/A	E2/ B	E2/ C	Site total
Marine																							
Anadara granosa	2	3			11	26	1	19	3	2			21	3				24	1	1	7	12	**136**
Anadara sp.				0												0			1				**1**
Anomalocardia squamosa														1									**1**
Clypeomorus bifasciata bifasciata								1															**1**
Donax cuneatus		1			8	3		2	0				4					6		1	2	1	**28**
Drupa morum morum					1																		**1**
cf. *Lioconcha* sp.													1										**1**
Nassarius olivaceus														1									**1**
Nerita rumphii						1			1				1			1							**4**
Ostreidae		1				2			1				1					1			1	1	**8**
Polyplacophora					1								0					0					**1**
Turbo cf. *petholatus*	1																						**1**
Subtotal (marine)	**3**	**5**	**0**	**0**	**21**	**32**	**1**	**22**	**5**	**2**	**0**	**0**	**28**	**5**	**0**	**1**	**0**	**31**	**2**	**2**	**10**	**14**	**184**
Freshwater/brackish water/mangrove																							
Batissa albertisii albertisii						1		1	1														**3**
Batissa sp.		3			10		1	16	9	5			34	6		5		8	4		23		**124**
Batissa subtrigona					1				1													1	**3**
Batissa violacea						1		1	4		1			1	0		1				3	18	**30**
Faunus ater		9	5		30	59	8	44	37	19			39	37		11	1	18	6		11	29	**363**
Geloina erosa								2					4	2				2				1	**11**
Batissa/*Geloina*								10		2			4										**16**
Batissa/*Geloina*—fragments		1		3	0	0	0		5	0				0		0		6	0	5	0	0	**20**
Melanoides cf. *arctecavus*						1																	**1**
Melanoides plicarius					4	5		4	3	3			7	4		2			1				**33**
Melanoides punctatus	1	3			4	6										2				1			**17**
Melanoides punctatus/*tuberculatus*							2	8	7	9			18	9		5		9				3	**70**
Melanoides sp.	1				2			3															**6**
Melanoides subgradatus	1				6	8		1	5	5			3	1		4		4				2	**40**
Neritidae fragments					3																		**3**
Neritina pulligera			1		9	6		12	6									3			1		**38**
Neritina waigiensis		1			5	1				1						4			2			2	**16**
Neritodryas cornea					1			2		1						1					2		**7**
Neritodryas subsulcata					1				1														**2**
Tarebia granifera						2			1					1		1							**5**
Subtotal (F/B/M)	**3**	**17**	**6**	**3**	**76**	**90**	**11**	**104**	**80**	**45**	**1**	**0**	**109**	**61**	**0**	**35**	**2**	**50**	**13**	**6**	**40**	**56**	**808**
Terrestrial																							
Coliolus cf. *thrix*						1			1	1													**3**
Cyclotus h. hebraicus					6	18	1	1	1	2			4	1				7	1	1	8	2	**53**
Dominamaria heretica		4			2	10		1	2				21					8		6	5	1	**60**
Pupinella tapparonei						1			1														**2**
Subtotal (terrestrial)	**0**	**4**	**0**	**0**	**8**	**30**	**1**	**2**	**5**	**3**	**0**	**0**	**25**	**1**	**0**	**0**	**0**	**15**	**1**	**7**	**13**	**3**	**118**
Total	**6**	**26**	**6**	**3**	**105**	**152**	**13**	**128**	**90**	**50**	**1**	**0**	**162**	**67**	**0**	**36**	**2**	**96**	**16**	**15**	**63**	**73**	**1110**

Table 11.3. Invertebrate remains recovered at site NGRP 46.

Square	Layer	Spit	Shell type	Habitat	Date excavated	Provenience
1	1	2	Cirripedia	marine	10/16/1996	NGRP 46/1/1/2
1A	1	2	*Batissa/Geloina*	F/B/M	10/15/1996	NGRP 46/1A/1/2
1A	2	1	*Anadara granosa*	marine	10/15/1996	NGRP 46/1A/2/1
1A	2	1	*Batissa* sp.	F/B/M	10/15/1996	NGRP 46/1A/2/1
1A	2	1	*Batissa/Geloina*	F/B/M	10/15/1996	NGRP 46/1A/2/1
1A	2	1	*Barbatia fusca*	marine	10/15/1996	NGRP 46/1A/2/1
1A	2	1	*Batissa/Geloina*	F/B/M		NGRP 46/1A/2/1
1A	2	2	*Batissa* sp.	F/B/M	10/16/1996	NGRP 46/1A/2/2
1A	2	2	*Anadara granosa*	marine	10/16/1996	NGRP 46/1A/2/2
1A	2	2	*Batissa* sp.	F/B/M	10/16/1996	NGRP 46/1A/2/2
1A	2	2	*Donax cuneatus*	marine	10/16/1996	NGRP 46/1A/2/2
1A	2	2	*Batissa a. albertisi*	F/B/M	10/16/1996	NGRP 46/1A/2/2
1A	2	2	*Geloina erosa*	F/B/M	10/16/1996	NGRP 46/1A/2/2
1A	2	3	*Mauritia a. arabica*	marine	10/16/1996	NGRP 46/1A/2/3
1A	2	3	*Anadara granosa*	marine	10/16/1996	NGRP 46/1A/2/3
1A	2	3	*Batissa* sp.	F/B/M	10/16/1996	NGRP 46/1A/2/3
1A	3	1	*Batissa/Geloina*	F/B/M	10/16/1996	NGRP 46/1A/3/1
1A	4	1	*Barbatia trapezina*	marine	10/17/1996	NGRP 46/1A/4/1
1A	4	1	*Periglypta puerpera*	marine	10/17/1996	NGRP 46/1A/4/1
1A	4	1	*Geloina erosa*	F/B/M	10/17/1996	NGRP 46/1A/4/1
1A	4	1	*Barbatia fusca*	marine	10/17/1996	NGRP 46/1A/4/1
1A	4	2	*Anadara granosa*	marine	10/17/1996	NGRP 46/1A/4/2
1A	4	2	*Conus litteratus*	marine	10/17/1996	NGRP 46/1A/4/2
1A	4	2	*Batissa/Geloina*	F/B/M	10/17/1996	NGRP 46/1A/4/2
1A	4	2	*Periglypta reticulata*	marine	10/17/1996	NGRP 46/1A/4/2
1A	5	1	*Faunus ater*	F/B/M	10/17/1996	NGRP 46/1A/5/1
1A	5	1	*Neritopsis radula*	marine	10/17/1996	NGRP 46/1A/5/1
1A	5	1	*Turbo argyrostomus*	marine	10/17/1996	NGRP 46/1A/5/1
1B	1	1	*Anadara granosa*	marine	10/14/1996	NGRP 46/1B/1/1
1B	1	2	*Barbatia fusca*	marine	10/15/1996	NGRP 46/1B/1/2
1B	1	2	*Periglypta reticulata*	marine	10/15/1996	NGRP 46/1B/1/2
1B	1	2	*Barbatia trapezina*	marine	10/15/1996	NGRP 46/1B/1/2
1B	2	1	*Batissa/Geloina*	F/B/M	10/15/1996	NGRP 46/1B/2/1
1B	2	1	*Anadara granosa*	marine	10/15/1996	NGRP 46/1B/2/1
1B	2	2	*Anadara granosa*	marine	10/17/1996	NGRP 46/1B/2/2
1B	2	2	*Periglypta puerpera*	marine	10/17/1996	NGRP 46/1B/2/2
1B	2	2	*Anadara antiquata*	marine	10/17/1996	NGRP 46/1B/2/2
1B	2	2	*Gafrarium tumidum*	marine	10/17/1996	NGRP 46/1B/2/2
1B	2	2	*Batissa/Geloina*	F/B/M	10/17/1996	NGRP 46/1B/2/2
1B	2	2	*Anadara antiquata*	marine	10/17/1996	NGRP 46/1B/2/2
1B	2	2	*Periglypta reticulata*	marine	10/17/1996	NGRP 46/1B/2/2
1C	1	2	*Turbo marmoratus*	marine	10/15/1998	NGRP 46/1C/1/2
1C	1	2	*Barbatia fusca*	marine	10/15/1996	NGRP 46/1C/1/2
1C	1	2	*Batissa/Geloina*	F/B/M	10/15/1996	NGRP 46/1C/1/2
1C	2	1	*Batissa* sp.	F/B/M	10/15/1996	NGRP 46/1C/2/1
1C	2	1	*Anadara granosa*	marine	10/15/1996	NGRP 46/1C/2/1
1C	2	1	*Geloina erosa*	F/B/M	10/15/1996	NGRP 46/1C/2/1
1C	2	1	*Batissa subtrigona*	F/B/M	10/15/1996	NGRP 46/1C/2/1
1C	2	1	*Batissa a. albertisi*	F/B/M	10/15/1996	NGRP 46/1C/2/1
1C	2	1	*Batissa violacea*	F/B/M	10/15/1996	NGRP 46/1C/2/1
1C	2	1	*Anadara granosa*	marine	10/15/1996	NGRP 46/1C/2/1
1C	2	1	*Batissa* sp.	F/B/M	10/15/1996	NGRP 46/1C/2/1
2	1	1	*Barbatia trapezina*	marine	10/18/1996	NGRP 46/2/1/1
2	1	1	*Batissa/Geloina*	F/B/M	10/18/1996	NGRP 46/2/1/1
2	1	1	*Conus* sp.	marine	10/18/1996	NGRP 46/2/1/1
2	1	2	*Barbatia trapezina*	marine	10/18/1996	NGRP 46/2/1/2
2	1	2	*Batissa* sp.	F/B/M	10/18/1996	NGRP 46/2/1/2
2	1	2	*Anadara granosa*	marine	10/18/1996	NGRP 46/2/1/2
2	1	2	*Periglypta puerpera*	marine	10/18/1996	NGRP 46/2/1/2
2	2	1	*Barbatia trapezina*	marine	10/18/1996	NGRP 46/2/2/1
2	2	1	*Batissa/Geloina*	F/B/M	10/18/1996	NGRP 46/2/2/1
2	2	1	*Mauritia a. arabica*	marine	10/18/1996	NGRP 46/2/2/1
2	2	1	*Anadara granosa*	marine	10/18/1996	NGRP 46/2/2/1
2	2	1	*Periglypta reticulata*	marine	10/18/1996	NGRP 46/2/2/1
2	2	2	*Gafrarium pectinatum*	marine	10/18/1996	NGRP 46/2/2/2
2	2	2	*Gyrineum* cf. *bituberculare*	marine	10/18/1996	NGRP 46/2/2/2
2	2	2	*Geloina erosa*	F/B/M	10/18/1996	NGRP 46/2/2/2
2	2	2	*Anadara granosa*	marine	10/18/1996	NGRP 46/2/2/2
2	2	3	*Nerita rumphii*	marine	10/19/1996	NGRP 46/2/2/3
2	2	3	*Anadara granosa*	marine	10/19/1996	NGRP 46/2/2/3
2	2	4	*Anadara granosa*	marine	10/19/1996	NGRP 46/2/2/4
2	2	5	*Anadara antiquata*	marine	10/19/1996	NGRP 46/2/2/5

TABLE 11.3. *Continued.*

Square	Layer	Spit	Shell type	Habitat	Date excavated	Provenience
2	2	5	*Anadara granosa*	marine	10/19/1996	NGRP 46/2/2/5
2	2	5	*Heterocentrotus mammillatus*	marine	10/19/1996	NGRP 46/2/2/5
2	3	1	*Anadara granosa*	marine	10/19/1996	NGRP 46/2/3/1
3	1	1	*Geloina erosa*	F/B/M	10/18/1996	NGRP 46/3/1/1
3	1	1	*Anadara antiquata*	marine	10/18/1996	NGRP 46/3/1/1
3	1	1	*Codakia tigerina*	marine	10/18/1996	NGRP 46/3/1/1
3	1	2	*Periglypta reticulata*	marine	10/19/1996	NGRP 46/3/1/2
3	1	2	*Faunus ater*	F/B/M	10/19/1996	NGRP 46/3/1/2
3	1	2	*Batissa* sp.	F/B/M	10/19/1996	NGRP 46/3/1/2
3	2	1	*Geloina erosa*	F/B/M	10/18/1996	NGRP 46/3/2/1
3	2	1	*Faunus ater*	F/B/M	10/18/1996	NGRP 46/3/2/1
3	2	1	*Gafrarium pectinatum*	marine	10/18/1996	NGRP 46/3/2/1
3	2	1	*Periglypta puerpera*	marine	10/18/1996	NGRP 46/3/2/1
3	2	1	*Batissa* sp.	F/B/M	10/18/1996	NGRP 46/3/2/1
3	2	1	*Pythia scarabaeus*	terrestrial	10/18/1996	NGRP 46/3/2/1
3	2	2	*Batissa* sp.	F/B/M	10/18/1996	NGRP 46/3/2/2
3	2	2	*Faunus ater*	F/B/M	10/18/1996	NGRP 46/3/2/2
3	2	3	*Anadara granosa*	marine	10/19/1996	NGRP 46/3/2/3
3	2	3	*Gafrarium pectinatum*	marine	10/19/1996	NGRP 46/3/2/3
3	2	3	*Batissa* sp.	F/B/M	10/19/1996	NGRP 46/3/2/3
3	3	2	*Batissa* sp.	F/B/M	10/20/1996	NGRP 46/3/2/3
3	2	4	*Periglypta puerpera*	marine	10/19/1996	NGRP 46/3/2/4
3	2	4	*Batissa* sp.	F/B/M	10/19/1996	NGRP 46/3/2/4
3	2	5	*Gafrarium pectinatum*	marine	10/19/1996	NGRP 46/3/2/5
3	2	5	*Periglypta puerpera*	marine	10/19/1996	NGRP 46/3/2/5
3	2	5	*Periglypta reticulata*	marine	10/19/1996	NGRP 46/3/2/5
3	3	1	*Batissa* sp.	F/B/M	10/19/1996	NGRP 46/3/3/1
3	3	1	*Periglypta reticulata*	marine	10/19/1996	NGRP 46/3/3/1
3	3	2	*Conus* sp.	marine	10/20/1996	NGRP 46/3/3/2
3	3	2	*Gafrarium pectinatum*	marine	10/20/1996	NGRP 46/3/3/2
3	3	3	*Batissa subtrigona*	F/B/M	10/20/1996	NGRP 46/3/3/3
3	3	3	*Barbatia fusca*	marine	10/20/1996	NGRP 46/3/3/3
3	3	3	*Gafrarium tumidum*	marine	10/20/1996	NGRP 46/3/3/3

F/B/M = Fresh/Brackish water/Mangrove

TABLE 11.4. Invertebrate taxa recovered at other sites.

Site	Location	Species
NGRP 9	Aitape, test pit 3, layer 1	*Turbo* cf. *petholatus*
NGRP 14	Aitape, test pit 5E, layer 1	*Tectus niloticus*
NGRP 30	Oumaipe, Kobom foothills, surface	*Geloina erosa**
NGRP 35	Old Aiterape, Kobom foothills, surface	*Anadara granosa*
		Ostreidae

* Freshwater/brackish water species; the rest are marine species.

TABLE 11.5. Shell artifacts.

Species	Provenience	Putative use; description	Figure
Anadara granosa	NGRP 46-3/3/1	net sinker; umbo perforated for attachment to fish net	11.14e
Cheilea sp.	NGRP 16-C3/C	ornament; pair of small perforations near the apex of the shell for attachment to object	11.15a
Clypeomorus bifasciata	NGRP 16-A3/1	ornament; pair of perforations in the dorsal body whorl for attachment to object	11.15b
Conus sp.	NGRP 46-3/3/2	gouge?	11.15f
Erosaria annulus	NGRP 16-B2/C	ornament; dorsum removed to facilitate sewing or binding to textile or other object	11.14b
Heterocentrotus cf. *mamillatus*	NGRP 46-2/2/5	nose ornament; unmodified	11.13c
Ovula ovum	NGRP 16-A2/C and NGRP 16-B2/B	ornament/pendant; hole drilled or naturally existing hole (by predatory gastropod) used for attachment with string	11.15e
Placuna ephippium	NGRP 16-A3/D	ornament; shell worked into roundish disks	11.14a
Tectus niloticus	NGRP 16-A3/D	ornament	11.15c
Tectus niloticus	NGRP 14-5E/1	ornament	11.15d
Tridacna sp.	NGRP 46-3/1/1	shell disc	11.14c
Tridacna sp.	NGRP 46-1B/1/1	shell ring (half)	11.14d

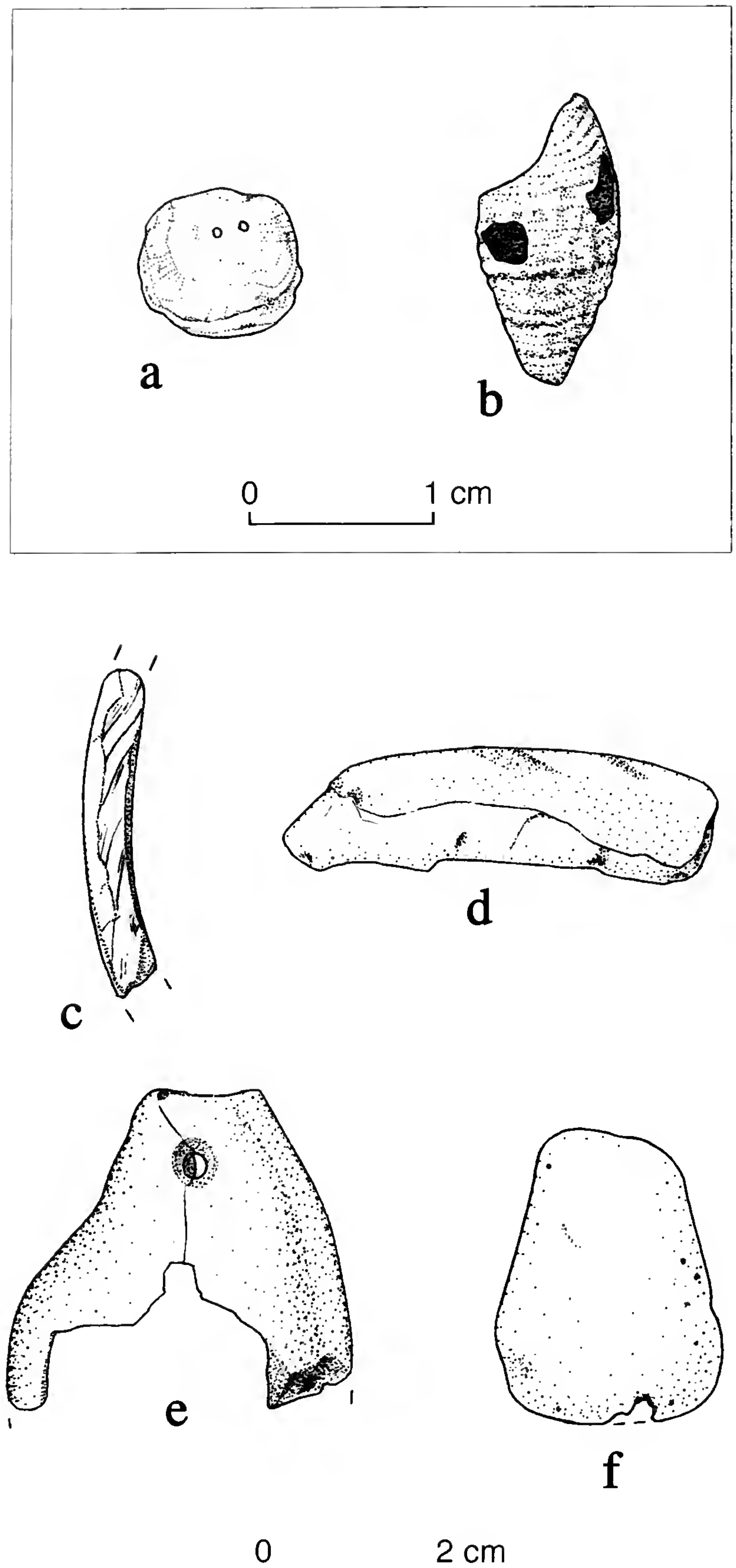

FIG. 11.15. Shell artifacts: (**a**) *Cheilea* sp., ornament, NGRP 16/C3/C; (**b**) *Clypeomorus bifasciata bifasciata*, ornament, 16/A3/1; (**c**) *Tectus niloticus*, ornament, 16/A3/D; (**d**) *Tectus niloticus*, ornament, 14/5E/1; (**e**) *Ovula ovum*, ornament/pendant, 16/A2/C and 16/B2/B; (**f**) *Conus* sp., ?gauge, 46/3/3/2.

this and similar genera eaten by people in New Guinea (Fig. 11.6g; Alan J. Kohn, pers. comm., 2002; van Benthem Jutting, 1940).

The shellfish remains recovered on Tumleo indicate the use of marine mollusks from the waters surrounding the island as well as estuarine and mangrove habitats on the mainland coast as food. The absence of all species more strictly limited to freshwater or only slightly brackish habitats, such as *Melanoides* spp., *Neritina* spp., and *Neritodryas* spp., show that molluscan food resources from further inland beyond the immediate coastal area were not exploited.

Other investigators have described aquatic mollusks in their excavations in northern Papua New Guinea: Fenner (1941, p. 336) lists *Arca granosa* (=*Anadara granosa*), *Neritina* sp., *Telescopium fuscum*, and *Cyrena coaxans* (=*Geloina erosa*) among others, and Swadling (1994, p. 132, 1997, p. 6) reports finding species including mainly *Terebralia palustris*, *Telescopium telescopium*, *Saccostrea echinata*, *Polymesoda* (*Geloina*) *coaxans* (=*Geloina erosa*), and *Anadara granosa*, which she dates to 5,800 BP. This is consistent with our findings, with the exception of *Terebralia palustris* and *Telescopium telescopium*, which are not major components attested in our study.

Shell Artifacts

Several shell specimens seem to have been altered by humans for purposes other than the extraction of the meat (Table 11.5, Figs. 11.14 and 11.15). It is probable that more specimens than those listed in the table were used as tools or had ornamental functions, but in some specimens where this is likely the case, either no signs of physical alteration are present or the specimens are too fragmentary to show signs of alteration. Examples are the fragmentary shells of the cowrie shell species *Erosaria erosa* and *Mauritia a. arabica* at NGRP 16 and 23 and the opercula of *Turbo* cf. *petholatus*, at NGRP 9, 16 and 23, which resemble eyes and are frequently used as such in contemporary artwork in the area.

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Chapter 12: Petrography of Coastal Sands and Prehistoric Sherd Tempers from the Northwestern Coast of Papua New Guinea

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Abstract

Petrographic study of the temper sands in fifty prehistoric potsherds from the mainland coast and nearby offshore islands of northwestern Papua New Guinea, and comparison of the temper sands with modern coastal sands of the region have shown that temper grains were derived from largely volcanogenic bedrock of the Torricelli Mountains and associated ranges lying inland from the coast. Temper aggregates include both natural tempers embedded in clay bodies and manually added tempers of both fluvial and beach origin, but all the tempers are generically similar, being composed of varied arrays of mineral grains and rock fragments with broadly common origins. Seven temper groups are defined petrographically on the basis of sand texture and mineralogy, and most or all can be identified from megascopic examination of sherds without microscopic analysis. Temper analysis provides no evidence for importation of pottery into the region from elsewhere, nor do any potsherds studied to date from the Bismarck Archipelago contain tempers indicative of ceramic transfer eastward from northwestern Papua New Guinea.

Introduction

Fifty prehistoric potsherds and five modern coastal sands for comparative study from northwestern Papua New Guinea were provided for temper analysis by John Terrell of the Field Museum of Natural History in Chicago, including samples from both the mainland coast and nearby offshore islands. The materials come from a reach of the coast 300 km long centered near Aitape, which lies approximately 150 km west of Wewak along the coastal flank of the Torricelli Mountains and related ranges between the mouth of the Sepik River to the east and the border with Papua on the west.

Petrographic examination of Sepik sherds was undertaken to establish the nature and probable origin of sand tempers embedded in the clay pastes with two main questions in mind:

1. Is their overall character different enough from Lapita and other tempers of the Bismarck Archipelago and Oceanian sites still farther to the southeast to allow reliable distinctions to be drawn, and confident recognition of intrusive wares if Sepik pottery has ever been transferred to islands beyond New Guinea or vice versa?
2. Is there enough longshore temper variation within the Sepik region to allow eventual documentation of east–west pottery transfer along the Papua New Guinea coast?

The answer to the first question is generally affirmative, as temper sands derived from the accretionary geotectonic province along the northern fringe of the combined Australia–New Guinea continental landmass are mineralogically more complex than any Oceanian temper sands (Dickinson, 1998a), but the answer to the second question is generally negative because sands and tempers of the Sepik region seem not to vary from place to place along the coast in any systematic fashion.

Torricelli Mountains Provenance

Mountainous tracts of northwesternmost Papua New Guinea are termed the Torricelli Mountains inland from Aitape, but carry other names to the east and west, including Prince Alexander Mountains south of Wewak and Bewani Mountains and Oenake Range near Papua (Hamilton, 1979). For simplicity here, as all the ranges expose generically similar bedrock, the entirety of the uplands between the east–west inland course of the Sepik River within Papua New Guinea and the coast to the north are treated as spurs and ranges of the Torricelli Mountains (cf. Mackenzie, 1976).

The coastal plains north of the Torricelli Mountains are underlain by undeformed Neogene (post-mid-Miocene) sediment accumulations. Although some modern sediment along the coast may well be recycled detritus stored temporarily in strata of the Neogene succession exposed on adjacent plains, the ultimate provenance of Neogene and modern sediment is inferred to be the same belt of highlands standing farther inland between the coast and the Sepik River. The bold ranges and uplands lying inland from the coastal plain are underlain by deformed and uplifted pre-mid-Miocene (mostly Paleogene) strata representing crustal elements of a pre-mid-Miocene island arc of intraoceanic character (Hamilton, 1979; Cullen & Pigott, 1989). The island-arc structure was accreted by collisional tectonics to the Australia–New Guinea continental block during Miocene times.

Information about the lithology of source rocks within the accretionary terrane is limited, but extrusive and intrusive igneous rocks, in part metamorphosed, and partly metamorphosed sedimentary rocks, typically volcaniclastic strata derived from volcanic sources, are all widespread (Hamilton, 1979). The higher parts of the Torricelli uplands are underlain by variably metamorphosed volcanic and volcaniclastic rocks (ranging from greenschist to amphibolite metamorphic grade), comagmatic plutons (dominantly gabbro-diorite but also including granitic rocks with more abundant quartz), and minor associated limestones of ancient reef complexes. The older volcanogenic strata of Paleocene-Eocene age are dominantly basaltic, but younger counterparts of Oligocene-Miocene age include abundant andesite as well as minor dacite and rhyolite. Upper Mesozoic plutonic and metamorphic basement, also of volcanogenic origin, is locally present beneath the Tertiary assemblages (Pigram & Davies, 1987). Derivative Torricelli detritus is expected to include volcanic, plutonic, metamorphic, and sedimentary debris of complex mineralogy from varied source rocks. Despite a paucity of specific lithologic information about the bedrock exposures, the general nature of accretionary island-arc terranes of intraoceanic origin, as well as the derivative detritus shed from them, is well known from work in the North American Cordillera and elsewhere around the compound circum-Pacific orogenic belt (e.g., Dickinson, 1970).

Sepik Coastal Sands

Thin sections were studied of modern shoreline sands from Leitere, Serra, Aitape, Yakamul, and Suain (in order from west to east along 155 km of coast). All the modern sands are generally well sorted but mineralogically heterogeneous aggregates composed of subrounded to subangular grains, including, in varying proportions, quartz, both feldspars, ferromagnesian minerals, and polycrystalline rock fragments, mainly igneous (dominantly volcanic or metavolcanic), but also including sedimentary–metasedimentary varieties. Both degree of rounding and percentage of rock fragments tend to increase, as expected, with grain size, which varies from fine to coarse sand. The two easternmost samples (Yakamul and Suain) are placer sands in which ferromagnesian mineral grains are much concentrated over their abundances in the nonplacer sands from farther west. Rare calcareous grains of modern reef detritus are present in one of the placer sands (Yakamul) and one of the nonplacer sands (Serra) but were not observed in the other sands. Opaque iron oxide grains of high specific gravity are a significant component of the placer sands, though not of the other sands, but represent a clearly environmental rather than provenance signal. The placer sands are somewhat better sorted and more rounded than the nonplacer sands, both properties being textural facets reflective of more intense sedimentary reworking to achieve placer concentration of heavy minerals on beach faces.

Grain Types

Grain types include a broad spectrum of mineral grains (monomineralic detritus) and rock or lithic fragments (polymineralic–polycrystalline detritus). The mineral grains represent crystals that occurred either as phenocrysts or microphenocrysts of sand size or larger in volcanic or metavolcanic source rocks, as constituent crystals of comparable size within coarser-grained intrusive igneous or metamorphic source rocks, or as sand grains in older clastic sedimentary rocks derived ultimately from comparable sources. The lithic grains represent fragments of source rocks with internal crystals smaller than sand size, and include natural samples of the groundmasses of volcanic and metavolcanic rocks, vein quartz, and varied sedimentary to metasedimentary rocks with internal crystals or clasts finer than sand size. Lithic fragments of igneous parentage are reported as volcanic or intrusive lithic fragments in cases where relict internal textures or fabrics are indicative of igneous origin even where magmatic minerals have been partly or wholly replaced by secondary pseudomorphs of nonmagmatic minerals during deuteric alteration, diagenesis, or metamorphism. Sand grains are classified into the following mineralogic or generic categories:

1. Quartzo-feldspar mineral grains (QF) include quartz (qtz), dominantly of intrusive igneous origin with trains of internal vacuoles and wavy extinction, and varied feldspars (F), including unaltered plagioclase (plg) from both volcanic and deeper-seated intrusive igneous or metamorphic sources, albite (alb) formed by metamorphic alteration of plagioclase, and minor K-feldspar (ksp), probably derived dominantly from intrusive igneous rocks. Albite grains commonly display microcrystalline inclusions of hydrous calcium-bearing aluminosilicates of the epidote or related groups.
2. Ferromagnesian mineral grains (FM) include hornblende (hbl), clinopyroxene (cpx), and orthopyroxene (opx) of dominantly igneous derivation from either volcanic or intrusive rocks, epidote (epi) in mainly polycrystalline aggregates produced by deuteric or metamorphic alteration of igneous rocks, and opaque iron oxides (opa) of uncertain but largely igneous derivation. Clinopyroxenes are dominantly colorless or pale green but nonpleochroic augite, orthopyroxenes are dominantly faintly pleochroic hypersthene with straight extinction, and hornblendes are dominantly pleochroic in green tints, although subordinate brown hornblende is also present.
3. Lithic fragments (LF), include diverse volcanic–metavolcanic (eruptive) igneous, hypabyssal–plutonic (intrusive) igneous, and sedimentary–metasedimentary types:
   a. Aphanitic volcanic–metavolcanic lithic fragments (VRF), with constituent mineral crystals too fine to discern with a hand lens, were derived from eruptive volcanic or volcaniclastic source rocks (lava flows and fragmental breccias or tuffs), or their metamorphosed equivalents, and include lathwork grains (lwk) composed of twinned plagioclase laths with interstitial volcanic glass and/or ferromagnesian minerals, and representing groundmasses of crystalline basaltic rocks; microlitic grains (mic) with tiny plagioclase microlites commonly either embedded in volcanic glass or accompanied by crystallites of ferromagnesian minerals, and representing groundmass fragments of either basaltic or andesitic rocks; felsitic grains (fel) composed of microcrystalline mosaics of quartz and feldspar, and representing groundmass fragments of rhyolitic to dacitic rocks; glassy grains (gls) composed dominantly of volcanic glass, both mafic and felsic, or its

cryptocrystalline alteration products; and neomorphic metavolcanic grains (nmv), typically microgranular amphibolites or foliated greenschists, lacking inherited volcanic textures or fabrics. Identification of grains of volcanogenic origin is commonly aided by the presence of tiny microphenocrysts within volcanic lithic fragments.

b. Phaneritic igneous (plutonic–hypabyssal) lithic fragments (PRF), with internal mineral crystals discernible but typically not identifiable with a hand lens, were derived from intrusive igneous rocks ranging from microcrystalline hypabyssal (hyp) dikes or sills to coarser subvolcanic plutons (plu). Both quartz-free mafic (gabbro-diorite) and quartz-bearing granitic fragments are represented among the latter. The distinction of broadly microgranular lithic fragments of intrusive igneous origin from various sedimentary and metamorphic lithic fragments was guided by the subhedral character of internal crystals typical of igneous fabrics in the former as opposed to rounded sedimentary clasts or more complexly intergrown crystals of metamorphic origin internal to the latter.

c. Sedimentary–metasedimentary lithic fragments (SMF), include polycrystalline quartzose grains (pqt) derived from vein quartz or metaquartzite, argillaceous grains (arg) derived from shale or argillite, microgranular quartz–mica grains (mgn) derived from hornfels or indurated siltstone, foliated quartz–mica tectonite grains (tec) derived from slate or phyllite, and chert–metachert grains (chm) composed of chalcedonic quartz forming a cryptocrystalline to microcrystalline mosaic of tiny equant crystals.

4. Calcareous grains (cal) of modern reef detritus are calcitic and aragonitic skeletal grains of coralline, algal, foraminiferal, and bivalve origin mixed with terrigenous grains derived from interior bedrock sources. As the calcareous grains are not diagnostic of provenance, grain percentages cited in Table 12.1 are recalculated free of calcareous grains, although the percentages of calcareous grains present, as a proportion of total sand grains, are also reported for reference (as "% total").

TABLE 12.1. Frequency percentages of grain types in coastal sands[a] of the Sepik region, northwestern coastal Papua New Guinea, based on traverse counts of 250 noncalcareous grains per thin section as recalculated free of any calcareous grains present. See text (Grain Types) for descriptions and symbols of sand grain types. LEI-SER-AIT are nonplacer sands, and YAK-SUA are related placer sands (see footnote for collecting localities).

	Grain size and locality				
	vfin-med	fin-coa	fin-coa	fin-med	fin-med
Grain type	LEI	SER	AIT	YAK	SUA
QF					
qtz	18	14	16	3	2
F					
plg	11	7	7	1	4
alb	8	11	11	3	4
ksp	1	2	1	1	1
(Total F)	(20)	(20)	(19)	(5)	(9)
[Total QF]	**[38]**	**[34]**	**[35]**	**[8]**	**[11]**
FM					
hbl	4	2	6	16	7
cpx	5	4	3	35	30
opx	1	tr	tr	tr	1
epi	7	6	7	10	10
opa	2	1	2	10	19
[Total FM]	**[19]**	**[13]**	**[18]**	**[71]**	**[67]**
LF					
VRF					
lwk	3	5	4	1	1
mic	5	11	8	3	3
fel	4	4	4	1	1
gls	2	1	3	2	1
nmv	3	5	5	3	2
[Total VRF]	**[17]**	**[26]**	**[24]**	**[10]**	**[8]**
PRF					
hyp	10	10	9	5	5
plu	7	5	6	2	2
[Total PRF]	**[17]**	**[15]**	**[15]**	**[7]**	**[7]**
SMF					
pqt	2	4	2	1	2
arg	3	2	2	2	2
mgn	2	2	2	tr	1
tec	1	1	1	—	1
chm	1	3	1	tr	—
[Total SMF]	**[9]**	**[12]**	**[8]**	**[4]**	**[6]**
(Total LF)	**(43)**	**(53)**	**(47)**	**(21)**	**(22)**
cal (% total)	—	tr	—	1	—

[a] Sand sample localities: LEI: Leitere, sample of modern potting temper; SER: Serra, beach sand at Serai Village; AIT: Aitape, beach sand near R.C. Mission; YAK: Yakamul, beach sand at Yakamul Village; SUA: Suain, beach sand at Lelep or Lelap Village.

Sand Compositions

The proportions of grain types in the coastal sand samples (Table 12.1) were determined by traverse frequency counts of 250 grains in each thin section, performed by determining the nature of the grains encountered beneath the microscope crosshairs along evenly spaced parallel tracks crossing the thin sections. A count of 250 grains serves to keep standard deviations of counting error below three percentage points for all grain types, and below two percentage points for grain types present in amounts less than 12% (Van der Plas & Tobi, 1965). These inherent uncertainties are judged to be generally less than the operator error associated with recognition of different grain types. Identification of many grain types, especially the different varieties of lithic fragments, involve subtle distinctions based not only on the optical properties of different minerals but also on the internal texture and fabric of individual sand grains.

The grain compositions of the three nonplacer sands (LEI-SER-AIT in Table 12.1) are similar in all qualitative respects, and effectively indistinguishable quantitatively in terms of any compositional parameters that are likely to be reproducible by multiple counts, especially if performed by more than one operator. The overall uniformity of the detritus in beaches at localities spread along nearly 100 km of the Sepik coast implies that reliable longshore areal differences in tempers representing coastal sands cannot be anticipated within the Sepik region. Although empirical differences may exist among fluvial sands in streams leading to the coast, any contrasts are apt to be quantitative rather than qualitative and hence difficult to document with confidence, and neither systematic nor predictable.

The two placer sands (YAK-SUA in Table 12.1) contain the same grain types as the nonplacer sands but display strong concentrations of ferromagnesian grains of high specific gravity. In both cases, pyroxene is the most abundant grain type, enhanced by a factor of five to 10 in the placer aggregates with respect to the nonplacer aggregates, but opaque oxide grains of even higher specific gravity show even greater relative concentration, by factors of 10 to 20. The ratio of pyroxene to hornblende is enhanced in the placer aggregates, perhaps because hornblende is more cleavable, subject to breakage and removal from the sand grain population by grain impacts during placer reworking. Epidote is also markedly reduced relative to pyroxene, probably because most of the epidote grains are compound polycrystalline aggregates that tend to disintegrate as a result of grain impacts. The total percentage of quartz and feldspar combined is only a quarter to a third of its value in the nonplacer sands, and lithic fragments of all categories are reduced to about half their abundances in the nonplacer sands. Lesser reduction for lithic fragments, in comparison to quartz and feldspar grains, is expected because lithic fragments contain minerals of both high and low specific gravity, yielding a bulk specific gravity intermediate between light and heavy minerals.

There is no indication that the placer sands reflect a different provenance than the nonplacer sands but instead reflect a different intensity of sedimentary reworking of the Torricelli detritus. It seems likely that related placer and nonplacer sands can be collected at suitable sites all along the coast of the Sepik region, with contrasts in sand composition controlled by the local distribution of placer and nonplacer deposits along the beachfront. The Sepik beach sands examined in thin section can thus be taken provisionally to define a coherent indigenous suite of generically related sands potentially available as temper all along the Sepik coast.

Temper Comparisons

The Sepik coastal sands differ fundamentally from most Oceanian temper sands, which are typically volcanic sands of the *oceanic basalt* and *andesitic arc* temper classes (Dickinson & Shutler, 1968, 1971, 1979, 2000; Dickinson, 1998a), neither of which contain any detritus from plutonic, metamorphic, or sedimentary source rocks. Related tempers of the *postarc cover* class (Dickinson & Shutler, 2000) are also dominantly volcanic sands. Sepik sands are also quite unlike tempers of the *tectonic mainland* (Dickinson & Shutler, 1968) or *tectonic highland* (Dickinson & Shutler, 1971, 1979, 2000; Dickinson, 1998a) temper class, known to date only from New Caledonia and Yap, which either contain quartz grains and quartzose sedimentary–metasedimentary detritus in much higher proportions than the Sepik sands or else were derived almost exclusively from ultramafic and/or metavolcanic source rocks. The Oceanian tempers most analogous to Sepik sands are those of the so-called *volcaniclastic orogen* (Dickinson and Shutler, 1968) or *volcano-tectonic orogen* (Dickinson & Shutler, 1971, 1979) or *dissected orogen* (Dickinson, 1998a; Dickinson & Shutler, 2000) temper class, which is composed of combined volcanic and plutonic and associated metamorphic and sedimentary detritus derived from parts of extinct or dormant island arcs where erosion has bitten deep into the intrusive roots of volcanogenic arc structures to tap both intrusive and surficial components of the crustal profile. Overall resemblance is not surprising given the accretionary island arc history of the Torricelli Mountain source rocks, uplifted and deformed tectonically to provide the provenance for Sepik coastal sands.

Dissected orogen tempers of island Oceania differ, nevertheless, from the Sepik sands in several key respects. Examples are known to date only in sherds from the Ryukyu Islands (Dickinson, 1981); Watom Island off New Britain, where dissected orogen temper in subordinate sherds is exotic to the locale and probably represents sand from the nearby New Britain mainland (Dickinson, 1998b); and several well-studied sites along the south coast of Viti Levu in Fiji (Dickinson, 1971, 1973, 2001; Dickinson et al. 1996). The ratio of epidote grains to other ferromagnesian silicate grains is uniformly much higher (~1:1 to ~1:2) in Sepik nonplacer sands than in any known dissected orogen tempers of island Oceania (<1:5), probably reflecting the higher proportion of varied meta-igneous source rocks, as opposed to unmetamorphosed igneous rocks, in the tectonically deformed accretionary terrane of the Torricelli provenance. Strongly metamorphosed metavolcanic lithic fragments composed of secondary minerals of neomorphic habit are also much more common, though still subordinate, in the Sepik sands. On the other hand, quartz grains are more abundant (~30%) in nonplacer dissected orogen tempers of Viti Levu, with feldspars also typically more abundant, although the dissected orogen tempers of probable New Britain origin in sherds from Watom contain somewhat less quartz (average 5–10%) than nonplacer Sepik sands (~15%). Nonigneous lithic fragments of any kind are absent or rare, however, in the Watom sherds, in which plagioclase feldspar is the predominant grain type (~60%). On balance, the Sepik sands are consistently more lithic rich than dissected orogen tempers from island Oceania, with lithic fragments representing roughly half the grain population in the nonplacer Sepik aggregates but forming only 10–30% of nonplacer dissected orogen tempers from island Oceania.

By far the most likely Oceanian arena for potential exchange or transfer of pottery with the Sepik region is the so-called Lapita Homeland of the Bismarck Archipelago (Allen & Gosden, 1991). Although appraisal of Bismarck Archipelago tempers is still in a reconnaissance phase, enough work has been done to show that essentially all, with the single exception to date of the feldspar-rich dissected orogen temper from New Britain in Watom sherds, are exclusively volcanic sands of either andesitic arc or aberrant rhyolitic and alkalic character (Dickinson, 1998b) but in either case quite unlike the Sepik coastal sands of heterogeneous provenance. Any exotic sherds of Sepik origin found within the Bismarck Archipelago should be readily detectable from temper petrography.

Sepik Sherd Tempers

The sherd tempers can be split into seven broad temper groupings, A–G (Table 12.2), which together represent a spectrum of sand composition denoted in the standard terminology of sedimentary petrology as lithofeldspathic to feldspatholithic aggregates, depending on the ratio of feldspar grains to lithic fragments. Overall, no pairs of tempers present identical matches, and gradational spectra of both textural and compositional variation are the general rule. Although some quartz is present in all the temper sands, none are markedly quartzose, and their general character is fully compatible with derivation from Torricelli bedrock exposures.

TABLE 12.2. Salient characteristics and distribution by provenience of seven salient temper groups (A–G) in prehistoric Sepik sherds (sherds listed from west to east provenience within each sublist for different temper groups).

Temper group	No. of sherds	Macroscopic characteristics	Specimen nos.	Locations
A	5	abundant, well sorted, rounded to subrounded, medium to coarse, nonplacer and noncalcareous, feldspatholithic temper sands of probable beach origin added manually to slightly silty fat clay bodies	601-1, 603-2 (2/4), 610 (1/5), 638 (1/1), 200 (1/1)	Leitere, Serra, Ali, Kep
B	5	sparse, well sorted, rounded to subrounded, medium to coarse, nonplacer and noncalcareous, lithofeldspathic temper sands of probable beach origin added manually to distinctly silty clay bodies	606-2, 609-1, 609-2 (3/5), 155-2, 171-2 (2/14)	Serra, Tarawai
C	9	abundant, moderately sorted, subangular to subrounded, fine to coarse, nonplacer and noncalcareous lithofeldspathic temper sands of probable beach origin added manually to distinctly silty clay bodies	601-2 (1/4), 606-1 (1/5), 615-3 (1/4), 153-2, 170-2 (2/14), 161-1, 162-1, 162-2, 163-B1 (4/7)	Leitere, Serra, Wom, Tarawai, Walis,
D	4	abundant, moderately sorted, subangular to subrounded, fine to coarse, nonplacer and noncalcareous feldspatholithic temper sands of probable fluvial origin added manually to distinctly silty clay bodies	156-2 (1/2), 615-1 (1/4), 155-1 (1/14), 163B-2 (1/7)	Ramu, Wom, Tarawai, Walis
E	10	abundant, poorly sorted, generally subangular, very fine to medium, nonplacer and noncalcareous lithofeldspathic (to feldspatholithic) sands that probably represent natural temper imbedded in silty alluvial clay bodies	156-1 (1/2), 615-2, 616 (2/4), 46-1A-11, 46-1A-22, 46-1A-42, 177-1, 178 (5/7), 154-1 (1/14), 161-2 (1/7)	Ramu, Wom, Tumleo, Tarawai, Walis
F	2	abundant natural temper of Group E type augmented by sparse manually added temper of rounded to subrounded beach sand including calcareous grains	177-2 (1/7), 176-2 (1/14)	Tumleo, Tarawai
G	14	abundant, well sorted, subrounded to subangular, fine to medium, variably placered but noncalcareous sand of probable beach origin manually added to variably silty clay bodies, with no apparent correlation between the siltiness of clay bodies and sites of sherd recovery	16-B-2B, 23A-C1, 23A-C2, 649-B1, 649-B2 (5/5), 46-1A-41 (1/7), 153-1, 154-2, 169-1, 169-2, 170-1, 171-1, 176-1 (7/14), 161-3 (1/7)	Aitape, Tumleo, Tarawai, Walis

Textural relations between temper sands and clay pastes suggest that some tempers may be natural temper embedded as sandy impurities in clay bodies, whereas others appear clearly to be manually added temper. Sedimentological factors, rather than provenance contrasts, probably account for most or all of the temper variations, meaning that empirical differences in temper composition are difficult to appraise in generic terms or to use for identification of nonlocal wares that may have been moved about within the Sepik region.

As all the temper groups contain the same categories of grain types, in varying proportions, as the coastal sands, quantitative frequency counts were not performed for the temper sands except to test tentative matches in the tempers of sherds from different places. Instead, visual estimates of grain abundances were made using the following semiquantitative scheme (Table 12.3): dominant, >50%; abundant, 25–50%; subordinate, 10–25%; minor, 1–10%; and rare, <1%.

TABLE 12.3. Semiquantitative mineralogical compositions of Sepik temper groups where D (dominant) ≥50%; A (abundant) = 25–50%; S (subordinate) = 10–25%; M (minor) = 1–10%; R (rare) ≤1%. Grain categories: QF, quartz and feldspars; FS, ferromagnesian silicates (pyroxene-hornblende-epidote); OO, opaque iron oxides; TLF, lithic fragments (total of all types).

Temper groups	Grain types			
	QF	FS[a]	OO[a]	TLF
A	A (to D)	M (to R)	R	A (to D)
B	D (to A)	M (to R)	R (to M)	A (to S)
C	D	R (to M)	M (to R)	A
D	A	M	R	D
E	A (to D)	M (to R)	R (to M)	A (to S)
F[b]	A	M	R	A
G	A (to S)	A (to S)	M (to S)	S (to A)

[a] FS + OO = FM (total ferromagnesian grains of Table 12-1).
[b] Also contain calcareous grains (see text for discussion).

Temper Census

One sherd (603-1) from Leitere on the far west of the Sepik coastal region does not group well with any other sherds, appears to be naturally tempered ashy soil rich in juvenile tephra, and is left out of tabulations here (Tables 12.2 and 12.3). As no Quaternary volcanoes occur along the northern coast of Papua New Guinea west of Vokeo, located in the Schouten Islands east of Wewak (Hamilton, 1979), the origin of this anomalous sherd is uncertain. My identification of volcanic ash in the sherd could be erroneous, but in any case the sherd has no close counterparts in the remainder of the sherd collection studied.

GROUPS A AND B (n = 10 in all, or a fifth of the sherd sample)—These are closely similar nonplacer beach sands manually added to clay pastes, with distinct contrasts in grain size between the finest temper grains and the coarsest nonplastic silt grains embedded within the clay pastes. The two groups differ in the amount of manually added temper (greater for group A), the siltiness of the clay pastes (greater for group B), and the ratio of QF mineral grains to lithic fragments (higher for group B). Such sands could conceivably be present anywhere along the Sepik coast, but more than half the group comes from either Leitere or Serra near the western end of the sampling area. Single sherds from Ali and Kep farther east and two sherds from the offshore island of Tarawai may have been transferred eastward from some place of manufacture farther west.

Groups C and D (n = 13 in all, or roughly a quarter of the sherd sample)—These differ from each other in a manner analogous to groups A and B in terms of ratio of QF mineral grains to total lithic fragments (higher for group C), and are also manually added tempers but are less rounded sands not as well sorted, and probably reflect fluvial rather than beach origin. Again, such sands could conceivably be present in drainages all along the Sepik coast, but most come from the offshore islands of Tarawai and Walis, to which they may have been transferred from the mainland, and most of the remainder from the central part (Ramu-Wom) of the coast near Aitape. The existence of sherds from Leitere with both group A temper (n = 2) and group C temper (n = 1), and from Serra with both group A and B tempers (n = 4) and group C temper (n = 1) suggests but fails to prove that sands interpreted here as having beach and fluvial origins were used for temper at or near the same sites at different times or by different potters.

Groups E and F (n = 12 in all, or nearly a quarter of the sherd sample)—These contain poorly sorted sand temper that grades downward in grain size toward the coarsest silt grains embedded in the pastes, and probably represent natural temper enclosed within alluvial clay bodies. The ferromagnesian grains include blocky prisms and acicular needles of brown hornblende as well as pyroxenes. The finer hornblende grains of irregular shapes are probably winnowed separately from the bulk of the grain aggregates forming typical coastal sands and beach sand tempers in which brown hornblende is not so prominent. The sherds of group F also include sparse manually added temper sand, which is coarser, better sorted, and rounded, and includes calcareous grains diagnostic of beach origin. Half the group E sherds come from Tumleo Island off Aitape, but their tempers display no attributes consistently different from comparable tempers in mainland sherds from Ramu and Wom just west of Aitape. It is a moot point with present information whether the sherds of group E were made at multiple sites with local materials of similar character or made only on Tumleo with either local or nonlocal materials or made on the mainland and transferred to the offshore islands of Tumleo, Tarawai, and Walis. If my interpretation of natural temper is valid, it seems most likely that the group E sherds were made on the mainland, for the occurrence of sandy alluvial clay seems unlikely for the offshore islands. On the other hand, the beach origin of the manually added hybrid (mixed terrigenous–calcareous) sands of group F, which occurs only in sherds from the offshore islands of Tumleo and Tarawai, may suggest that mainland clays were transferred to the islands and further tempered there with local beach sands before firing. Beach sands could also be obtained, of course, on the mainland coast, so that inference of offshore manufacture is inherently ambiguous.

Group G (n = 14 in all, or nearly a third of the sherd sample)—These are well sorted and generally similar though variably placered beach sands added manually to clay bodies with variable silt content that does not correlate with sites of sherd recovery. Pyroxene, hornblende, and epidote sand grains are present in variable proportions in all the sherds of group G. All the sherds from Aitape (n = 5) on the mainland and half those (n = 7) from the offshore island of Tarawai contain group G temper sands, and both subsets of sherds could well be of local manufacture unless Tarawai

Table 12.4. Frequency percentages of grain types in group A (Tables 12.2 and 12.3) Sepik tempers (medium-coarse lithic-rich beach sands) based on areal counts of all sand grains present in thin sections. See text (Grain Types) for descriptions and symbols of sand grain types.

	Sherd and locale (count)				
Grain type	**601-1 Leitere (175)**	**603-2 Leitere (200)**	**610 Serra (100)**	**638 Ali (185)**	**200 Kep (105)**
QF					
qtz	19	20	25	18	17
F					
plg	14	10	11	8	12
alb	14	20	4	13	17
ksp	2	1	1	2	1
(Total F)	**(30)**	**(31)**	**(15)**	**(23)**	**(30)**
[Total QF]	**[49]**	**[51]**	**[41]**	**[41]**	**[47]**
FM					
hbl	1	1	1	1	3
cpx	1	2	—	3	1
opx	—	—	—	—	—
epi	4	3	—	6	6
opa	—	—	—	—	—
[Total FM]	**[5]**	**[6]**	**[1]**	**[10]**	**[10]**
LF					
VRF					
lwk	3	2	4	2	1
mic	10	8	9	11	7
fel	5	2	2	2	4
gls	—	tr	1	tr	—
nmv	1	2	1	3	1
[Total VRF]	**[19]**	**[14]**	**[17]**	**[18]**	**[13]**
PRF					
hyp	10	12	14	12	17
plu	6	4	9	8	4
[Total PRF]	**[16]**	**[16]**	**[23]**	**[20]**	**[21]**
SMF					
pqt	2	4	6	3	3
arg	3	2	4	2	3
mgn	4	2	5	2	3
tec	1	1	—	2	—
chm	1	4	3	2	—
[Total SMF]	**[11]**	**[13]**	**[18]**	**[11]**	**[9]**
(Total LF)	**(46)**	**[43]**	**[58]**	**[49]**	**[43]**
Cal (% total)	—	—	—	—	1

beaches expose only calcareous sands (information unavailable to me). Additional sherds (only one each) from the offshore islands of Tumleo and Walis may also contain either local or nonlocal tempers, depending on the sedimentology of island beaches. As an island as small as Tarawai is unlikely to harbor a wide range of sand deposits, sherds from Tarawai containing group B and E tempers were probably transferred to Tarawai from mainland sites, and the same can be said of sherds from nearby Walis containing group C and D tempers.

Matching Tests

Three petrographic tests were conducted using frequency counts to gauge how well the sherd tempers of selected temper groups can be matched with one another or with coastal sands: (a) abundant lithic-rich beach sands of group A, (b) sparser and less lithic-rich beach sands of group B, and (c) variably placered beach sands of group G. For group A, to

TABLE 12.5. Frequency percentages of selected grain types and related grain groupings in Group B (Tables 12.2, 12.3) Sepik tempers (medium-coarse feldspar-rich beach sands) based on areal counts of all sand grains present in thin sections. See text (Grain Types) for descriptions and symbols of sand grain types.

	Sherd and locale (count)				
Grain type	**606-2 Serra (125)**	**609-1 Serra (105)**	**609-2 Serra (75)**	**155-2 Tarawai (95)**	**171-2 Tarawai (135)**
QF					
qtz	23	22	36	34	33
Total F	33	26	24	38	41
[Total QF]	**[56]**	**[48]**	**[60]**	**[72]**	**[74]**
FS					
hbl	—	1	—	—	—
pyx[a]	2	3	tr	2	1
epi	2	3	—	2	3
[Total FS[b]]	**[4]**	**[7]**	**[tr]**	**[4]**	**[4]**
opa	—	5	—	—	—
(Total LF)	**(40)**	**(40)**	**(40)**	**(24)**	**(21)**

[a] pyx = cpx (clinopyroxene) + opx (orthopyroxene).
[b] Total FS (total ferromagnesian silicates) = total FM − opa (total ferromagnesium-opaque iron oxides).

TABLE 12.6. Frequency percentages of selected grain types and related grain groupings in group G (Tables 12.2 and 12.3) Sepik tempers (variably placered fine-medium beach sand) based on areal counts of 250 grains per thin section in sherds from Aitape on the mainland and the islands of Tumleo, Tarawai, and Walis. See text (Grain Types) for descriptions and symbols of sand grain types.

	Grain type					
	QF	**hbl**	**pyx[a]**	**epi**	**opa**	**TLF**
Aitape						
16-B-2B	49	9	9	3	3	29
23-A-C1	54	8	4	1	1	32
23-A-C2	42	5	8	6	6	33
649-B1	37	4	14	7	11	27
649-B2	47	2	8	4	1	38
Tumleo						
46-A-41	35	5	8	4	2	46
Tarawai						
153-1	37	4	3	12	6	38
154-2[b]	20	3	27	2	4	44
169-1[b]	14	8	25	5	6	42
169-2	43	1	3	5	1	47
170-1	40	2	2	8	2	46
171-1	34	6	12	4	6	38
176-1	47	4	4	12	4	29
Walis						
161-3[b]	26	1	11	15	24	23

[a] pyx (total pyroxene) = cpx + opx.
[b] Placer sand aggregates.

provide full comparison with the samples of modern coastal sand, the same categories of grain types were counted in the same detail (Table 12.4). For group B, feldspars were counted together, and all lithic fragments also were lumped together (Table 12.5) because the numbers of grains present in each thin section are too few to allow reliable statistical estimates of relative abundances of feldspar varieties and different lithic grain types. For group G, a heterogeneous subset of sands, quartz, and feldspar were counted jointly, and lithic fragments were again lumped (Table 12.6), but ferromagnesian minerals were each counted separately as indicators of the petrologic character of detritus.

GROUP A—Tempers were counted to establish whether sherds containing them may have been manufactured at the same site and distributed widely by exchange or trade. Although such a possibility cannot be wholly excluded, given the overall generic similarity of the group A temper sands, the compositional data make that possibility seem unlikely. The two group A tempers from Leitere are essentially indistinguishable, given the inherent statistical uncertainties of the counts in combination with the difficulty of making positive identifications of some grain types, but the group A tempers from three other sites differ from the Leitere tempers in ways unlikely to be either statistical or petrographic artifacts. The group B tempers in sherds from Ali and Kep might conceivably reflect a common origin, but the Ali-Kep tempers differ from both the Leitere and the Serra tempers, especially in their higher contents of ferromagnesian silicate mineral grains. As the latter can be achieved, however, by local placer concentration, the conclusion that Ali-Kep and Leitere group B tempers probably came from different places is not robust. Even so, the most conservative interpretation of the group A tempers, though provisional, is that sands of appropriate sedimentological character are available at multiple sites along the Sepik coast. The most pervasive difference between group A tempers and modern coastal sands is the comparative paucity of ferromagnesian grains in the former (Tables 12.1 and 12.4), but this contrast can be understood as a function of the coarser grain size of the group A tempers. Proportions of ferromagnesian grains, especially opaque iron oxides, are expected to decline with grain size because of a comparative lack of coarse ferromagnesian crystals in typical source rocks.

GROUP B—Tempers were counted to determine whether sherds from Tarawai containing group B temper could have come from near Serra, where a majority of the sherds examined contain group B temper. Table 12.5 shows that inference to be unlikely. Group B tempers from Serra are similar sands, especially in their identical content of lithic fragments, although one is distinctly impoverished in ferromagnesian silicate grains in comparison to the other two. Both the group B tempers from Tarawai, however, contain fewer lithic fragments than the Serra tempers, with correspondingly higher percentages of total quartz–feldspar grains. Although sherds from Tarawai containing group B temper may nevertheless have come from somewhere along the mainland coast, origin near Serra can apparently be excluded.

GROUP G—Tempers were counted to discover whether beach sand tempers from different sites differ in any systematic ways, and to learn whether such tempers resemble modern coastal sands. Table 12.6 shows that within-site variations and between-site variations among the group G tempers are comparable, with the exception of selected placer sands with anomalously high contents of one or more ferromagnesian minerals, which otherwise vary unsystematically in percentage. Fortuitously, the group G temper in a sherd from Tumleo is virtually identical in its composition to modern nonplacer coastal sands, and the combined array of prehistoric sherd tempers and modern sand samples seems generally to represent a gradational spectrum of related

TABLE 12.7. Average percentages of key grain groupings in key generic (placer to nonplacer) or geographic subsets of Sepik sand samples and sherd tempers. See text (Grain Types) for descriptions and symbols of sand grain types.[a]

Sherd subset	Data	No. sherds in average	Grain group		
			QF	FM	LF
Placer sands	Table 12.1	2	10	68	22
Walis P	Table 12.6	1	26	51	23
Tarawai P	Table 12.6	2	17	40	43
Tumleo NP	Table 12.6	1	35	19	46
Nonplacer sands	Table 12.1	3	36	16	48
Tarawai NP	Table 12.6	5	40	20	40
Aitape	Table 12.6	5	46	22	32
Group A tempers	Table 12.4	5	46	6	48
Group B Serra	Table 12.5	3	55	5	40
Group B Tarawai	Table 12.5	2	73	5	22

[a] P = placer; NP = nonplacer.

materials lacking any sharp compositional discontinuities that might correlate with site geography (Table 12.7).

Megascopic Temper Analysis

Petrographic reconnaissance of Sepik sherd tempers thus leads to ambiguities regarding temper sources that further detailed petrography probably cannot resolve. Sands of varied character are doubtless widespread within the Sepik region, but the geographic scale of potential temper variation is essentially unknown. Although systematic differences in sands available may involve sizable tracts of contrasting ground, all the prehistoric sherd tempers and coastal sands contain generically similar detritus, and it seems equally possible that all or most of the sand variants observed to date could have been collected within a few kilometers of any given locale along the Sepik coast. Establishing the actual geographic scale of sand variation in the field would require sedimentological investigations difficult to achieve, given problems of access and cover, and perhaps quixotic because of landscape changes over the past few thousand years. If sand variations are geographically intricate, as between fluvial, beach, and placer sands, there is also no guarantee that any single village or even any individual potter always exploited the same sand deposit, whether local or nonlocal, for temper.

Even if a suitable control matrix could be constructed by geologic investigations, sorting the overall sherd collection by petrographic methods would remain impractical on two scores. First, analysis of any significant fraction of the sherd suite would require the preparation of so many thin sections that the cost would become an unattractive way to invest available resources. Second, fully documenting the subtle differences in temper type in a statistically defensible manner requires time-consuming frequency counts. Operator counting variance, whether from person to person or over a period of time by the same person, would be difficult to keep within the limits needed for confident interpretations.

The only feasible way to survey temper variations in the sherd suite as a whole, in a cost-effective way, is to turn to megascopic examination of the sherds with calibration provided by petrographic characterization. With that thought in mind, the sherds available to me have been examined with a hand lens in hopes of defining aspects of the tempers that can be discerned without microscopic study. If the sherd tempers can be sorted with success by megascopic analysis, then the distribution of various temper types within and between sites could be used as an aid to deciding which tempers are local and which are nonlocal. The exercise could still prove fruitless if all or most temper types are present at all or most sites, but at least the pattern of the full database could be established.

Megascopic Temper Criteria

LEITERE SHERD 603-1—This, with anomalous glassy ash (?) temper, has a dominantly smooth, nongritty surface unlike any of the other Sepik sherds.

GROUP A AND B TEMPERS—These are displayed megascopically as evenly sized and visibly rounded coarse sand grains protruding from sherd surfaces. Group A tempers generally appear more abundant than group B tempers, except that sherd 200 seems to group megascopically with group B more than group A in that respect, whereas sherd 171-2 seems to group megascopically with group A more than group B. These apparent reversals of sherd grouping suggest that distinction between groups A and B cannot be made with full confidence megascopically but that most sherds can be sorted correctly into one or the other of the two groups without petrographic study.

Group A and B beach-sand tempers can be distinguished megascopically from group C and D fluvial-sand tempers by the greater angularity, poorer sorting, and less protrusive character (from sherd surfaces) of the latter, but the subtle compositional distinction between groups C and D cannot be made megascopically with confidence (and probably is not generically significant in any case). The only group C and D sherd available to me that might be confused with groups A and B, after close examination, is sherd 615-3.

SHERDS WITH GROUP E TEMPERS—Interpreted here as natural temper, these generally lack the coarse temper grains visible in groups A and B as well as groups C and D, displaying only fine sand grains among which dark shiny ferromagnesian grains (the hornblende) are as prominent as pale grains. The only group E sherd available to me that might be confused megascopically with groups C and D is sherd 154-1, but microscopically it clearly belongs to group E from the abundance of brown hornblende crystals. This example suggests that some fraction of group E natural tempers contain as much fluvial sand as some manually added group C and D tempers. In one group F temper (sherd 177-2), representing group E temper to which calcareous grains have been added, the white calcareous grains are both oversized and prominent, but in the other group F temper (sherd 176-2), the calcareous grains are so small and sparse that it cannot be distinguished readily from group E tempers.

GROUP G TEMPERS—These have no salient characteristic that sets them apart from all other tempers, but they are generally well sorted fine to medium sands, finer grained than group A and B tempers, better sorted than group C and D tempers, and both more abundant and visibly more prominent than group E and F tempers. The unusual opaque-rich placer sand from Walis (161-3) is so fine grained, however, that it could be confused with natural temper (group E). Only actual

TABLE 12.8. Salient megascopic criteria (as visually calibrated with reference to sherds examined in thin section) for recognition of key temper subsets in Sepik sherds.

Group	Megascopic criteria for identifying temper
A and B	well sorted and visibly rounded coarse sand (more abundant in A than in B)
C and D	poorly sorted, generally angular medium sand (mean of fine-coarse range)
E and F	natural temper lacking coarse or abundant temper grains (beach sand with calcareous grains added to derive group F tempers from group E tempers)
G	typically well sorted and abundant fine sand with both pale and dark grains

attempts to sort sherds megascopically can show how effective the differences in grain size and sorting can be in separating group G tempers with confidence from the others, but there seems a reasonable chance for success.

Megascopic Sherd Sorting

On balance, then, megascopic criteria (Table 12.8) should allow distinctions to be made with a satisfactory level of confidence among group A and B, C and D, E and F, and G tempers (four subsets), with further separation of group A from B and group E from F in many or most instances (two more subsets). As the six subsets represent essentially the full array of temper types that can be distinguished on the basis of petrography (Table 12.2), future emphasis should probably be on systematic megascopic appraisal of the sherd suite, using the petrographic observations for calibration of visual appearance, rather than on any additional petrography unless specific questions arise for selected sherds.

Concluding Remarks

Modern sands and sherd tempers from the Sepik coastal region of northwestern Papua New Guinea form a related array of both placer and nonplacer aggregates derived from bedrock of the accretionary island-arc terrane of the Torricelli Mountains and related nearby ranges. The materials studied reveal no systematic longshore variations in sand or temper composition, but the distribution of temper groups at various sites on the mainland and nearby offshore islands suggests but fails to prove that transfer of wares from site to site was common within the Sepik region. From petrography alone, however, almost all specific instances of suggested pottery transfer are inherently ambiguous. On the other hand, mineralogical comparisons of the heterogeneous Sepik beach sands and tempers with the contrasting tempers known to date from island Oceania should allow clear-cut petrographic detection of sherds, if there were any, taken from the Sepik region to the Bismarck Archipelago or vice versa. At present, there is no extant petrographic evidence for prehistoric transfer of pottery in either direction. On balance, petrographic study of the Sepik sherd suite supports previous inferences (Dickinson & Shutler, 1968, 1971, 1979, 2000) that petrographic reconnaissance of prehistoric sherds leads to more clear-cut results for small islands, where bedrock sources are restricted in petrologic character, than for larger landmasses, where mixing of detritus from multiple source rocks is common in sediment dispersal systems that tap inherently varied bedrock exposures and spread similar detritus over wide areas.

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Chapter 13: Provenience Investigations of Ceramic and Obsidian Samples Using Laser Ablation Inductively Coupled Plasma Mass Spectrometry and Portable X-Ray Fluorescence

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Abstract

Explaining the modern cultural and linguistic diversity present on the Sepik coast requires an understanding of long-term interaction on both a regional and a broader Melanesian scale. To assess the nature of prehistoric social networks, 438 obsidian specimens and 326 ceramic sherds collected from the coast and brought to the Field Museum of Natural History in Chicago were subjected to chemical analysis by either laser ablation inductively coupled plasma mass spectrometry or portable X-ray fluorescence. The results indicate that people living on the Sepik coast received obsidian from sources in the Admiralty group and on New Britain continuously for the past 2,000 years, and possibly as far back as the mid-Holocene. While obsidian from New Britain is more abundant in contexts believed to pre-date ~2,000 BP, the more proximal Admiralty sources dominate later assemblages. Ceramic exchange may have begun between production centers on the coast as early as 2,000 years ago, and spanned the length of the coast by at the latest 1,000 BP. Regional differences in the degree and scope of exchange relationships evident in the recent past may have very ancient roots—the present data suggest that social networks on the coast were comparable to those ethnographically documented, and that sometimes quite proximal sites obtained materials from different sources or networks of exchange partners.

Introduction

The complex cultural and linguistic situation along the Sepik coast of Papua New Guinea (PNG) is likely the result of a number of factors, one of which may be the centrality of the region relative to movement between Southeast Asia and island Melanesia (Terrell, 2004, pp. 605–606). It would be of interest to measure the degree to which people living along this coast have been in contact with one another and with people over time elsewhere in the voyaging corridor (Irwin, 1992) to determine whether isolation or contact has primarily characterized the human history of the region (Terrell, 2001, pp. 212–213). While biological/genetic, linguistic, and material cultural classifications lead to hypotheses about how interaction or isolation has impacted linguistic and cultural diversity over time, they do not provide concrete chronologically anchored information regarding interaction patterns during pre- and protohistory. While only a proxy measure of human interaction, the study of the movement of material objects in the past does provide a temporally anchored measure of both direction and intensity of contact. It is not necessary to argue that every object exchanged in the past represented a face-to-face contact between producer and final consumer during which other aspects of culture or language were also transmitted, but connections archaeologically revealed by the movement of goods represent *potential* pathways through which less archaeologically visible aspects of culture could have been transmitted. Does it appear that people in the past lived in relatively isolated groups possibly representing ancestral language communities, or did the extensive social connections linking a diversity of speech communities that exist today (Chapter 2) also exist in the past? Can the Sepik coast during prehistory be viewed as a "community of culture"? To use the conceptual framework previously advanced by Welsch and Terrell (1998, pp. 51–52), can the overlapping boundaries of the *social fields* in which people along the Sepik coast lived and interacted over time be reconstructed?

This chapter reports on the results of chemical analyses of obsidian and ceramics from the Sepik coast and beyond (Fig. 13.1) collected primarily during the A. B. Lewis Project of the Field Museum of Natural History (Chapter 4) using inductively coupled plasma mass spectrometry with laser ablation sampling (LA-ICP-MS) and portable X-ray fluorescence (p-XRF). While the chief anthropological goal was to measure the degree to which people along this coast had contact both with one another and with people elsewhere over time, the initial goal was to assess the potential of these analytical techniques for determining the production or quarrying location of objects recovered from archaeological contexts on the Sepik coast—a goal typically referred to as "sourcing" or "proveniencing" in archaeological terminology.

Pioneering work by a number of Australian researchers has established that chemical characterization is effective in

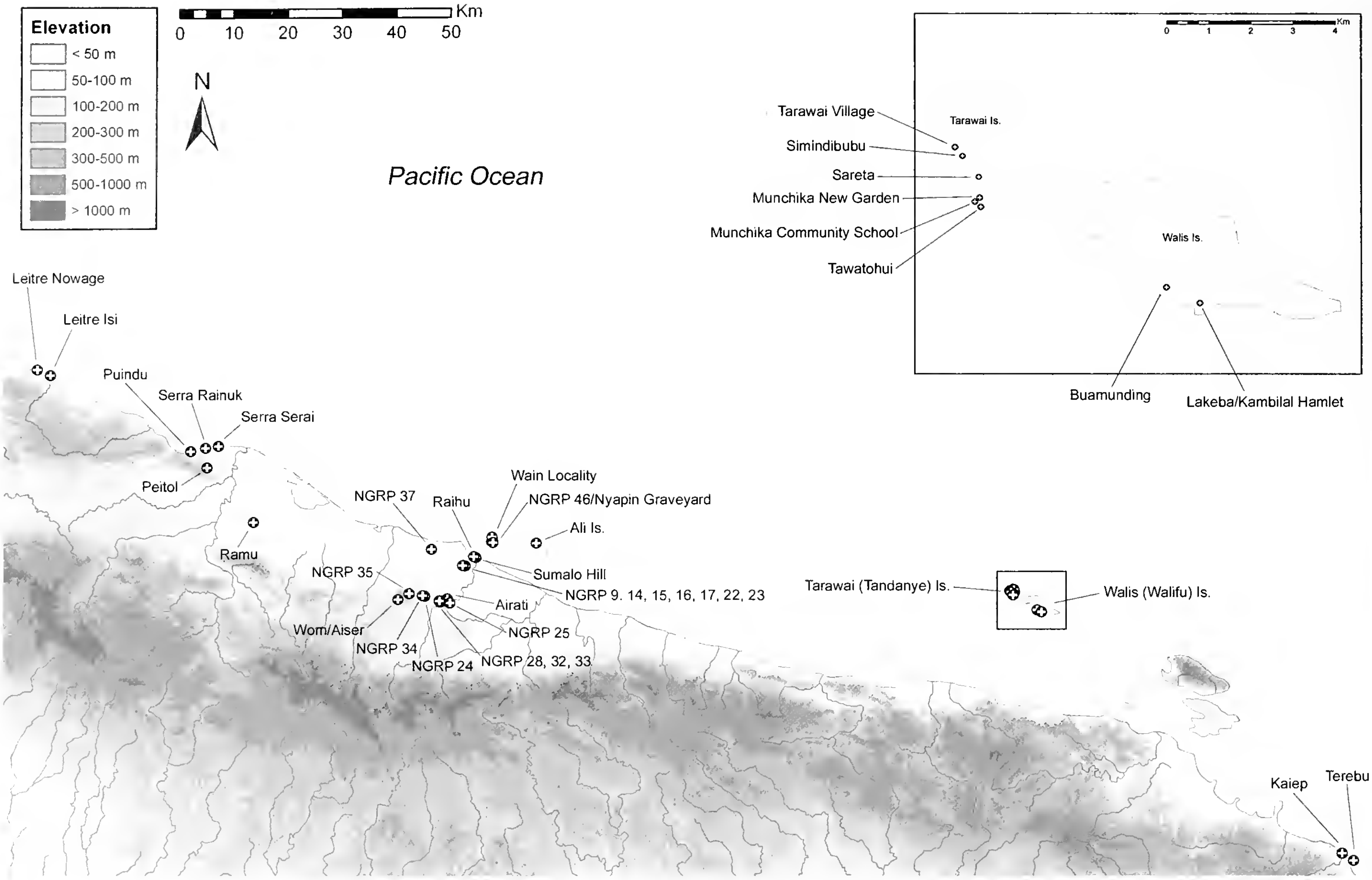

FIG. 13.1. The Sepik coast with localities mentioned in the text indicated.

discriminating between obsidian sources in the southwestern Pacific (Summerhayes et al., 1998). However, these studies used proton induced gamma ray/X-ray emission (PIGME-PIXE) for chemical characterization, requiring instrumentation that is costly and not widely available. Operating in a museum context, the Department of Anthropology at the Field Museum was interested in testing the applicability of more widely available nondestructive or minimally destructive techniques for sourcing artifacts. ICP-MS is capable of detecting a large number of elements at very low concentrations, and when laser ablation sampling is used, this technique is virtually nondestructive for small artifacts. Similarly, p-XRF is rapid, cost effective, and completely nondestructive although not as sensitive or capable of detecting as many elements as LA-ICP-MS. The goal of the studies reported here was to develop a sourcing methodology that is minimally destructive and maximally cost and time effective while still producing secure sourcing assignments. Anthropologically, the obsidian analyses undertaken provide a way to assess the degree of contact between people living on the Sepik coast and elsewhere in Melanesia, as obsidian sources do not exist along the Sepik coast itself.

The ability of chemical characterization to source ceramics from the Sepik coast was unknown at the beginning of the work reported here. Dickinson's petrographic results (Chapter 12) provided suggestive but not definitive results regarding production locations for the sample of coastal ceramic sherds he studied. It was hoped that chemical analysis could provide a complementary source of information, leading to secure source assignments for Sepik coast ceramics. Two principal related anthropological/archaeological questions were addressed by the ceramic analyses. First, could pots that had been exchanged between locales be identified among the prehistoric ceramics collected by Welsch and Terrell, giving some preliminary indication of the volume of exchange between different parts of the Sepik coast over time? Second, were pottery wares (e.g., Nyapin, Sumalo, Aiser, and Wain) known from particular locations along the coast produced only at those locations, or was production of these wares more broadly distributed?

Methods

LA-ICP-MS

ICP-MS is rapidly becoming an important method in archaeology for characterizing a broad spectrum of material types. In comparison with techniques such as PIGME-PIXE, XRF, and instrumental neutron activation analysis, ICP-MS generally has lower detection limits, and is able to accurately measure concentrations of far more elements very rapidly. This makes it ideal for analyzing large sets of samples. The ICP-MS functions by sending a sampled material in either liquid or aerosol form into a superheated (~8,000°C) argon plasma that ionizes the constituent atoms. These then pass into a mass spectrometer where they are sorted according to their mass/charge ratio and measured by a detector (Holmes et al., 1995; Kennet et al., 2001; Taylor, 2001). Elemental

TABLE 13.1. Isotopes measured by LA-ICP-MS.

Lithium (^{7}Li)	Silicon (^{30}Si)	Titanium (^{49}Ti)	Nickel (^{60}Ni)	Yttrium (^{89}Y)	Antimony (^{121}Sb)	Neodymium (^{146}Nd)	Holmium (^{165}Ho)	Lead ($^{206, 207, 208}$Pb)
Beryllium (^{9}Be)	Phosphorus (^{31}P)	Vanadium (^{51}V)	Copper (^{65}Cu)	Zircon (^{90}Zr)	Cesium (^{133}Cs)	Samarium (^{147}Sm)	Erbium (^{166}Er)	Bismuth (^{209}Bi)
Boron (^{11}B)	Chlorine (^{35}Cl)	Chromium (^{53}Cr)	Zinc (^{66}Zn)	Niobium (^{93}Nb)	Barium (^{137}Ba)	Europium (^{153}Eu)	Thulium (^{169}Tm)	Thorium (^{232}Th)
Sodium (^{23}Na)	Potassium (^{39}K)	Manganese (^{55}Mn)	Arsenic (^{75}As)	Silver (^{107}Ag)	Lanthanum (^{139}La)	Gadolinium (^{157}Gd)	Ytterbium (^{172}Yb)	Uranium (^{238}U)
Magnesium (^{24}Mg)	Calcium (^{44}Ca)	Iron (^{57}Fe)	Rubidium (^{85}Rb)	Indium (^{115}In)	Cerium (^{140}Ce)	Terbium (^{159}Tb)	Lutetium (^{175}Lu)	
Aluminum (^{27}Al)	Scandium (^{45}Sc)	Cobalt (^{59}Co)	Strontium (^{88}Sr)	Tin (^{118}Sn)	Praseodymium (^{141}Pr)	Dysprosium (^{163}Dy)	Hafnium (^{178}Hf)	

concentrations are calculated by measuring a series of standards with known concentrations alongside each batch of samples, which also controls for instrument drift over time.

Two general methods of sample introduction are typically utilized in archaeological applications. Laser ablation (LA), as the name would suggest, uses a laser to vaporize a small amount of a sample, which is then swept into the mass spectrometer by a gas, typically argon or helium. This method has the distinct advantage of being minimally destructive. Ablation spots are typically on the order of 50–200 μm in diameter, and cannot be seen with the naked eye. Ablation also requires little or no sample preparation as long as the object to be analyzed is small enough to fit into the laser sample chamber used (Gratuze et al., 2001; Speakman & Neff, 2005). As a point sampling technique, it is ideal for characterizing homogeneous materials such as obsidian, and numerous studies have utilized LA-ICP-MS to successfully distinguish between different sources (Glascock, 1999; Gratuze, 1999; Tykot, 2002).

A second method, microwave digestion (MD), involves dissolving a sample in acid under pressure and heat created by bombarding the sample with microwaves. While providing bulk characterization, this technique is time consuming and expensive, is destructive to the analyzed samples, involves caustic acids, and involves the potential for sample contamination (Kennet et al., 2001; Tsolakidou et al., 2002). Acid dissolution also has been demonstrated to differentially recover elements contained in differing phases within ceramic bodies, sometimes complicating the interpretation of results (Triadan et al., 1997). While MD-ICP-MS has been successfully utilized to distinguish between production locations of Lapita ceramics from Fiji and the Bismarck Archipelago (Kennet et al., 2004), a number of studies have demonstrated that LA-ICP-MS, with all its attendant advantages, can similarly provide reasonable characterization of the clay fraction of archaeological ceramic bodies (Larson et al., 2005; Beck & Neff, 2007; Dussubieux et al., 2007).

Analyzing only the clay paste also avoids the need to take into account temper chemistry when interpreting results (Neff et al., 1988, 1989; Summerhayes, 1997). The downside is a moderate loss of precision arising from measuring only some of an inherently heterogeneous material. However, as Dickinson's temper analysis had shown that Sepik coast ceramics were tempered with heterogeneous sand tempers, it was felt that analysis of the clay phase alone might provide more easily interpretable results.

All ICP measurements in the present study were made using the Varian Quadrupole ICP-MS housed at the Museum's Elemental Analysis Facility (EAF), with sample introduction via a New Wave UP213 laser ablation system. This system uses a 213 nm wavelength laser run at 70% energy (0.2 mJ) and a pulse frequency of 15 Hz. A helium/argon carrier gas sweeps the ablated material into the argon plasma, where it is ionized and passed into the mass spectrometer. There the ion beam is bent through a 90° angle using an ion mirror, increasing sensitivity by as much as 200× over a conventional quadrupole array. For most elements, the instrument can measure accurately to the subparts per million (ppm) level (Elliot et al., 2004). The ICP-MS was set to peak jumping mode with one point per peak and a dwell time of 18,000 μs. The entire mass range was scanned three times per replicate, with a total of nine replicates per measurement spot for a total of ~60 seconds of acquisition time. The first three replicates were removed from the final signal average to control for surface contamination and allow the signal to stabilize.

Isotopes of 52 major, minor, and trace elements were measured (Table 13.1). Instrumental sensitivity for measured trace elements ranges between 1 and .0001 ppm, with the majority between .01 and .001 ppm (Dussubieux et al., 2007, p. 354). For ceramics, no preparation was required beyond the production of a clean broken edge. Clays were ground in an agate mortar, wetted with ultrapure deionized water, formed into small briquettes, and fired for one hour at 900°C. Ten 100-μm-diameter spots were ablated per sherd, and the measured values averaged. Visible inclusions and pore spaces were avoided, and ablation was constrained to the center of each sherd cross section to avoid the effect of possible slips or edge contamination.

Four standard reference materials (SRMs) were run before and after each batch of samples, NIST610 and 612 glass standards, NIST standard clay 679 (Brick Clay), and New Ohio Red standard clay, which was run as a quality assurance standard and not used to calculate sample concentrations. In addition to certified values, other elemental concentrations for glass SRMs were obtained from Pearce et al. (1997). The New Ohio Red clay utilized at the Museum was obtained from Ronald Bishop at the National Museum of Natural History, Washington, D.C. The clay standards were fired into briquettes at the Field Museum in the same way described for clay samples.

Concentration values were calculated by first subtracting a blank value, then dividing each measurement by its corresponding value for ^{29}Si, which was used as an internal standard signal to control for time variation in ablation efficiency. This was also done for the SRMs, and a linear regression line (least squares fit) was then derived from them.

Si-normalized signals for the unknowns were compared to this regression line, summing all values to 100% to convert from silica-normalized relative concentrations to oxide weight percentages. These were then converted to ppm concentrations using multipliers for assumed most abundant oxides present in the samples. Although not every element is measured, those omitted are assumed to be of such low abundance (totaling only a few ppm or less) as to have no significant impact on the final calculated values. This method is essentially that first proposed by Gratuze et al. (2001) and modified by Speakman and Neff (2005).

While error values between measurements for the clay standards at the Museum laboratory were initially reported as ~10–25% for most trace elements (Dussubieux et al., 2007, p. 355), methodological improvements have reduced these values. As can be seen (Table 13.2), many elements have associated errors below 10% RSD over the course of the analyses reported here. Other elements, for instance, the lanthanide series, have errors in the 10–20% range. As, Ag, and Hf all have associated errors in excess of 20%, and were removed from further analysis as a result. Anomalously high Sb concentrations were also found in some sherds, although this element measured with good precision in the standards. Sb was consequently also removed from further consideration, as it is present in very minor amounts and contributed no significant patterning to the data.

The accidental analysis of two separate pairs of sherds from the same pots, TW15312A/B and TM001/003, demonstrates that measurements on the real archaeological ceramics are reproducible. In both cases, element by element variability between measurements was similar to those obtained for New Ohio Red clay, suggesting that the precision values listed in Table 13.2 are a good approximation for Sepik coast ceramics. When treated as separate samples, every clustering algorithm utilized grouped these two pairs before any other sherds, demonstrating that each is more similar to their corresponding double than to any other sherds measured. The two measurements were subsequently averaged and treated as a single measurement for purposes of further analysis.

Nine whole pots in the Museum's New Guinea collections were analyzed using an adaptable laser chamber recently acquired by the EAF: a New Wave Macro266 Laser unit (266-nm laser) that has been modified by Richard Cox (Université du Québec à Chicoutimi) such that a small laser chamber can be sealed onto the surface of whole vessels. This is particularly useful when dealing with museum collections for which it is critical to minimize analysis-related damage. In this case, the standards are placed inside the chamber, and a full set is run alongside each sample. Concentration values are then calculated in the same manner as for the normal laser chamber. Although measurements on standards indicated a degree of difference for some elements between our standard laser chamber and this adaptable chamber, comparison for all three standards indicates a very strong linear correlation between measured (adaptable chamber results) and expected (normal chamber results), with Pearson's r^2 values of no lower than 0.97 for any element. A linear least squares regression line was derived from the standard values as measured in the two chambers, and the concentration values obtained with the adaptable laser chamber corrected to make them comparable to measurements obtained with the regular laser chamber. The only constant exception was Hf, for which measurements obtained with the adaptable chamber were essentially random,

TABLE 13.2. Results of 50 measurements of New Ohio Red Standard Clay (ppm).[a]

Element	Average ± SD	%RSD
Li	147.12 ± 9.21	6%
Be	3.29 ± 0.37	11%
B	128.68 ± 15.52	12%
Na	1,252.56 ± 210.71	17%
Mg	9,649.08 ± 395.24	4%
Al	101,234.78 ± 3,493.71	3%
Si	314,826.61 ± 4,613.21	1%
K	35,681.26 ± 1,581.50	4%
Ca	1,493.30 ± 242.03	16%
Sc	19.69 ± 1.47	7%
Ti	5,328.56 ± 465.93	9%
V	217.34 ± 17.65	8%
Cr	91.94 ± 3.61	4%
Mn	324.49 ± 62.74	19%
Fe	40,885.19 ± 1,802.71	4%
Co	23.95 ± 1.58	7%
Ni	77.84 ± 3.95	5%
Cu	20.47 ± 1.98	10%
Zn	117.53 ± 7.29	6%
As	**11.80 ± 2.61**	**22%**
Rb	195.19 ± 14.65	8%
Sr	71.05 ± 5.71	8%
Y	28.93 ± 4.38	15%
Zr	146.39 ± 29.93	20%
Nb	23.11 ± 2.16	9%
Ag	**0.10 ± 0.03**	**34%**
In	0.09 ± 0.01	16%
Sn	4.11 ± 0.44	11%
Sb	**1.15 ± 0.10**	**8%**
Cs	10.37 ± 1.17	11%
Ba	600.63 ± 46.95	8%
La	40.49 ± 5.19	13%
Ce	97.52 ± 14.54	15%
Pr	10.04 ± 1.59	16%
Nd	35.87 ± 6.07	17%
Sm	6.96 ± 1.03	15%
Eu	1.60 ± 0.20	13%
Gd	5.97 ± 1.01	17%
Tb	0.95 ± 0.13	13%
Dy	5.28 ± 0.78	15%
Ho	1.11 ± 0.11	10%
Er	3.11 ± 0.33	11%
Tm	0.48 ± 0.05	9%
Yb	3.41 ± 0.39	12%
Lu	0.53 ± 0.06	12%
Hf	**5.04 ± 3.03**	**60%**
Pb	14.88 ± 1.77	12%
Bi	0.42 ± 0.05	13%
Th	14.51 ± 1.67	11%
U	3.08 ± 0.42	14%

[a] SD = standard deviation; RSD = relative standard deviation. Elements in bold were omitted from the analysis.

and often several orders of magnitude higher than those measured using the regular chamber. At present, it is unclear what is causing this problem, but for the time being, Hf has been omitted from further analysis. Given the near-perfect positive correlation between Zr and Hf concentrations measured in most ceramics (almost all the Hf in most ceramics is contained in mineral zircon, not the clay mineral component), this did not result in the loss of any significant compositional information.

As obsidian is generally very homogeneous internally, only four 55-µm spots were ablated per sample, and only in rare cases did percent relative standard deviations between measurements exceed 5%. Six external standards were run with each batch of samples: NIST610 and 612 glass standards, Brill's Corning B and D glass standards (Brill, 1999), and Sierra de Pachucua and Glass Buttes obsidians (Glascock, 1999). Percent relative standard deviations between measurements for the obsidian and glass standards are generally on the order of 1–3%.

p-XRF

X-ray fluorescence has a long history of use in archaeology as a means of determining the chemical composition of artifacts. An XRF device consists of an anode-cathode array that accelerates electrons toward a metal target, producing X-rays at a well-defined energy. This incident X-ray beam is then used to excite a sample material by removing electrons from the inner valence shells of its constituent atoms. As electrons in the outer valence shells drop into these vacant inner positions, they release energy in the form of secondary, or "fluorescent," X-rays that are measured by a detector. The multiple valence positions produce a series of characteristic energy peaks (the K and L α and β lines being the being the primary ones measured), the height of which is related to the concentrations of those elements in the sample. Advantages of XRF include lower cost per sample, rapid analysis (~5 minutes per sample or less), and high precision (~5% error for most elements). However, the X-ray beam typically penetrates only a short distance into the sample (~20 μm), and fluorescent properties are highly dependent on the density and composition of the matrix being analyzed (Rice, 1987, pp. 392–395).

The recent development of miniaturized X-ray sources and detectors has allowed for the application of portable X-ray fluorescence devices to obsidian sourcing (Cecil et al., 2007; Phillips & Speakman, 2009). Although limits of detection are typically higher than for lab-based XRF, p-XRF is fully capable of detecting trace elements such as Sr, Rb, and Fe at concentrations present in most obsidian flows. Because obsidian is typically highly homogeneous, measurement without any sample preparation is possible, and produces results good enough to assign samples to sources (Craig et al., 2007, pp. 2013–2014).

The Museum recently acquired an Innov-X systems Alpha™ portable X-ray fluorescence device. As currently configured, X-rays are produced with this device using a tungsten target, and are collected by a Si PIN diode detector, with an energy resolution of less than 230 eV FWHM at the 5.95 keV Mn Kα line. The device has two basic analysis modes that assume different sample matrices: "alloy" for matrices composed primarily of heavy elements such as metals, and "soil" for matrices composed primarily of light elements. For obsidian analysis, the device was set to the "soil" mode, which was assumed to be more appropriate for a predominantly Si-Al matrix. In this mode, a 40 keV, 20 μA beam is used to excite the target. Data were collected for a total of 60 seconds per sample. While in principle the p-XRF device is capable of measuring up to 32 elements spanning the range between P and U, in practice only 10 to 11 elements were present at high enough concentrations to be measured: K, Ca, Ti, Mn, Fe, Zn, Rb, Sr, Zr, Nb, and Ba.

In the present study, the fundamental parameters program supplied by Innov-X systems™ was used to calculate concentrations. Repeated analysis of a single piece of obsidian, SARR010, analyzed as part of the present study (Table 13.3), shows that precision using this analysis protocol is on the order of 5% for K, Ca, Mn, Fe, Rb, Sr, and Zr, while Ti, Zn, Nb, and Ba are in the 10–15% range, which is certainly adequate for the purposes of distinguishing between obsidian sources, as elemental concentrations vary far more than this between sources. In particular, Rb, Sr, Fe, and Zr, elements that prior PIGME-PIXE analyses indicate are particularly important for source and subsource discrimination between Melanesian obsidian flows, all have low associated error values (10% or less). SARR010 was selected as a "typical" sample in that it covered most but not all of the instrument aperture, and had a slightly irregular surface. Therefore, any imprecision resulting from these factors should be included in the reported values.

Table 13.3. Precision values derived from 10 measurements of obsidian sample SARR010 by p-XRF.[a]

Element	Mean ± SD	%RSD
K	32,006 ± 1,531	5%
Ca	8,312 ± 470	6%
Ti	1,822 ± 184	10%
Mn	481 ± 31	6%
Fe	17,467 ± 558	3%
Zn	59 ± 9	15%
Rb	146 ± 6	4%
Sr	77 ± 6	8%
Zr	400 ± 13	3%
Nb	41 ± 5	13%
Ba	615 ± 73	12%

[a] SD = standard deviation; RSD = relative standard deviation.

In the present study, accuracy was not rigorously tested, but a rigorous assessment of accuracy using the EAF p-XRF is reported in Williams et al. (in review). In the future, running several known obsidian standards alongside samples should allow for the correction of our results to make them more directly comparable to published values and those obtained by LA-ICP-MS.

Statistical Treatment of Data

Obsidian sources generally are chemically distinct enough to classify simply by visual inspection of bivariate elemental plots, and require no additional statistical testing. In contrast, the linking of ceramics to source areas or production locales via measurement of trace element chemistry requires the application of multivariate statistical techniques. The ultimate goal is the formation of chemical "reference groups"—groups of potsherds that are chemically representative of production in a locale or region (Bishop et al., 1988, pp. 318–319; Bishop & Neff, 1989, p. 66)—and ideally are completely distinct from one another in the multivariate space defined by measured concentrations. This typically involves using a series of multivariate statistical techniques aimed at both identifying likely chemical groups, testing the distinctiveness of these groups relative to one another, and then comparing unassigned samples to them. In practice, this involves calculating the probability that a given potsherd belongs to one group as opposed to others (Harbottle, 1976, p. 61; Glascock et al., 2004, pp. 100–101).

In the present study, elemental concentrations were logged to eliminate scaling differences between low- and high-abundance elements, after which principal components analysis (PCA) was performed as a means of reducing patterning in the full set of measured elements onto a smaller number of variables axes. A variant of PCA known as simultaneous R-Q mode factor analysis was utilized, allowing for the display of both object scores and elemental factor loadings on a single plot (Neff, 1994). On the basis of patterning evident after these steps, initial chemical groupings were formed for sites or regions by first removing ceramic sherds that were believed to be potentially nonlocal based on either stylistic, visual (paste), or petrographic characteristics. These initial chemical groups were then refined by calculation of jackknifed probabilities of group membership as derived from Mahalanobis distance from group centroids (the multivariate mean).

Mahalanobis distance is the squared Euclidean distance in the hypergeometric space defined by measured elemental concentrations between a data point and the centroid of the group to which it is being compared divided by the variance of the comparison chemical group in the corresponding direction, summed over all elements. This is the multivariate equivalent of calculating the z-score for a univariate measurement, and takes in account both the position of a sherd relative to other samples in a given chemical grouping and the hypergeometric shape of the group in question. Membership probabilities themselves are calculated using Hotelling's T-test (the multivariate version of Student's t-test). When comparing the statistical separation of potential reference groups, so-called jackknifed probabilities are calculated for samples relative to the groups they are initially placed in. Jackknifing refers to removing each sherd included in a postulated group in turn, recalculating the group mean and standard deviation, and then calculating the corresponding membership probability. This prevents sherds that should not be assigned to a particular group from stretching its statistical boundaries, resulting in erroneous assignments.

Calculation of Mahalanobis distance is a matrix operation performed using the variance–covariance matrix of the chemical group to which a sherd is being compared. The calculation requires that this matrix have a minimum of two more rows (objects included in the chemical group) than columns (elements or variables used to define the chemical group). Although principal components scores can be used instead of elemental concentrations to reduce the number of variables included in the calculation, rigorous statistical testing of small chemical groups is nonetheless difficult. The multivariate statistical "size" of a chemical group may be significantly overestimated when there are less than three to five times as many samples as variables, resulting in overestimated probabilities of membership.

A further test of multivariate group separation utilized in the current study is canonical discriminant function analysis (CDA). This technique determines axes of maximum variance between groups defined by the analyst—new scores for each sherd relative to the new discriminant function axis are then calculated. An additional function axis is required for each additional group included, meaning that there will be one fewer new variable axis defined than the number of groups included in the analysis. Ungrouped sherds can then have scores calculated relative to these functions, and be compared to predefined chemical groupings in this manner. This is essentially the "Brookhaven-MURR" approach to ceramic chemical data analysis, and has been described in detail elsewhere (Bieber et al., 1976; Harbottle, 1976, pp. 43–60; Bishop & Neff, 1989; Baxter, 2001, p. 135; Glascock et al., 2004, pp. 98–101).

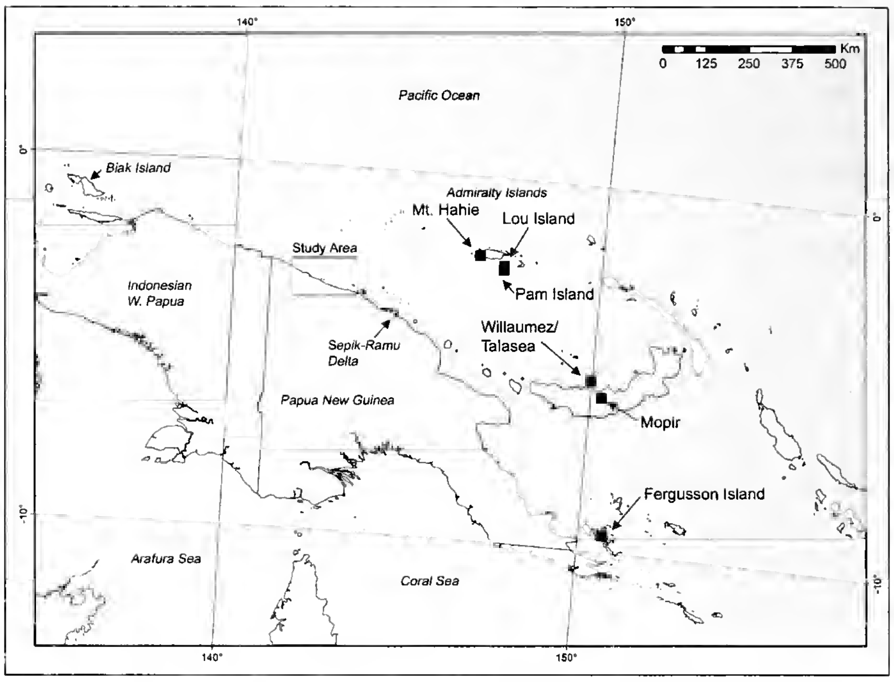

FIG. 13.2. Western Melanesia showing the location of obsidian sources.

Obsidian Analyses

Obsidian Exploitation and Exchange in Melanesian Prehistory

There are four major source areas for obsidian in Melanesia (Fig. 13.2): the Admiralty Islands, New Britain, Fergusson Island (D'Entrecasteaux Group), and the Banks Islands (Bird et al., 1997, p. 61; Fredericksen, 1997, p. 376). Of these, two source areas are now known to have been of importance in northern Melanesia: the Admiralty Islands, and New Britain.

Obsidian is found in three localities in the Admiralties: Lou Island, the Pam Islands, and Manus Island. Both Lou Island and the Pam Islands contain several obsidian subsources. On Lou Island, Umrei, Umleang, and Wekwok were extensively mined during prehistory, though it is known that there are also a number of obsidian sources now buried by volcanic eruptions that were used in the distant past. The Pam Islands contain two subsources, but one of these (Pam Mandian Island) yields obsidian of poor quality, and it is likely that Pam Island obsidian utilized in the past was quarried on Pam Lin Island. Obsidian from a third source area on Manus (Mount Hahie) appears to have never been moved off that island, while a fourth source on Tuluman Island was formed only in 1954 and has no archaeological relevance (Ambrose et al., 1981; Fredericksen, 1997, pp. 68, 70; Kennedy, 1997, p. 85; Summerhayes, 2003, p. 136).

On New Britain, there are a number of distinct obsidian sources on the Willaumez peninsula—Kutau/Bao, Gulu, Hamilton, and Baki/Garala—and another important source near Mopir. The Willaumez sources are also referred to in the archaeological literature as "Talasea" obsidian, the name that will be used in this chapter.

Of these five major New Britain sources, Kutau/Bao obsidian was most widely moved off New Britain Island in prehistory, although all were used on New Britain itself, and Mopir obsidian was moved off New Britain itself on occasion as well (Specht, 1981; Fullagar et al., 1991; Fredericksen, 1997, p. 376; White & Harris, 1997, pp. 104–105; Summerhayes, 2004). The chemical compositions of these sources and subsources have been extensively measured using PIGME-PIXE by Australian researchers: all subsources have been chemically distinguished from one another (Specht, 1981;

Ambrose & Duerden, 1982; Best, 1987; Duerden et al., 1987; Fullagar et al., 1991; Bird et al., 1997; Summerhayes et al., 1998).

Obsidian has been moved in the voyaging corridor for the past 20,000 or more years, with the earliest evidence indicating movement between different regions of New Britain, and later between New Britain and New Ireland (Summerhayes, 2004, pp. 145–146; Torrence et al., 2004, pp. 116–118). Most Talasea obsidian flows date to 30,200 years ago or slightly later, though the important flows at Kutau/Bao may be substantially younger than this, and the initiation of movement of different raw materials may reflect the date at which they first became available for use (Bonetti et al., 1998, p. 281; Torrence et al., 2004, p. 114). However, it was not until 8,000 BP that Talasea obsidian reached as far as the Admiralty group to the west, and not until 5,000 BP that it reached Nissan Island to the east (Allen, 1996, pp. 18–19, 23; Fredericksen, 1997, pp. 376–377; Torrence et al., 2004, pp. 113, 117).

Admiralty obsidian from an unknown source that may have been destroyed or covered by later volcanism was first exploited between 12,000 and 11,000 BP. After 8,000–6,000 BP, Pam Island obsidian was transported or exchanged within the Admiralty Islands (Fredericksen, 1997, pp. 379–380), and is usually the predominant type present at sites in the Admiralty Islands. Lou Island obsidian has been shown to be the primary type exported during prehistory to locales beyond the Admiralties but does not appear in the archaeological record in large quantities until about 3,000 BP (Summerhayes, 2003, pp. 135). However, a recent study sourced an obsidian object recovered on Biak Island dating to the mid-Holocene to the Umleang flow on Lou Island (Torrence & Swadling, 2008, p. 610).

According to Fredericksen and other researchers, obsidian movement and exchange networks expanded considerably during the Lapita period (3,300–2,200 BP), with New Britain (Kutau/Bao) obsidian reaching the Mussau group, Buka, the Reefs/Santa Cruz group, Tikopia, Vanuatu, and New Caledonia (Green, 1987; Fredericksen, 1997, p. 378). Farther to the east, small amounts of Kutau/Bao material have been found at early Lapita sites in the Fiji archipelago (Best, 1987, p. 31). Late in the Lapita period, small amounts reached westward as far as eastern Malaysia (Bellwood & Koon, 1989, pp. 614, 617, 620).

Admiralty Islands obsidian is known to have had a similar distribution during the Lapita period, reaching as far westward as Borneo and out into Micronesia as well as most of the regions where New Britain obsidian has been found, including northern New Guinea. Most of this archaeological material is known to have come from Lou Island sources, though at some sites about one-quarter originated from the Pam Island sources (Fredericksen, 1997, pp. 380, 382–383; Summerhayes, 2003, p. 137).

Within the Bismarck Archipelago, changes in the distribution of obsidian occurred during the Lapita period, with a dominance of Talasea obsidian at the majority of non-Admiralty sites during the early Lapita period (3,500–3,000/2,900 BP). During the middle Lapita period (2,900–2,700/2,600 BP), Admiralty obsidian dominates site assemblages on New Ireland and northern New Britain, with the distribution of Talasea obsidian focused at sites in the southern part of New Britain. In the late Lapita period (2,700/2,600–2,200 BP), Talasea obsidian once again came to dominate the assemblages at most sites in the Bismarcks.

The post-Lapita period in the Bismarcks (generally said to begin after ~2,200 BP; Summerhayes, 2004, p. 151) saw the development of a sharp division between New Ireland and islands to the east of there, where Admiralty obsidian was predominantly exchanged on one hand, and New Britain, where Talasea and Mopir obsidians were predominantly utilized, a pattern that continued into ethnographic times (Summerhayes, 2004, pp. 150–151). Kirch (1990, 1991) sees this as representative of a general contraction in the spatial scope of exchange networks in Melanesia, with the eventual development of the ethnographically known intensive local networks such as the *kula*, which seems to have developed within the past half millennium. In contrast, White (1996, p. 204) has argued that obsidian distribution and exchange networks have expanded over time.

Prehistoric Obsidian Use on the New Guinea Mainland

Isolated finds of stemmed obsidian tools dating between 3950 and 1650 cal BC at sites on the New Guinea mainland indicate that peoples living there were connected into broader Melanesian networks of exchange prior to the appearance of Lapita pottery (Araho et al., 2002, p. 72). Examples have been recovered at sites in the Sepik-Ramu delta region—for instance, at Mangum village—and have been sourced to the Kutau/Bao source on New Britain. These stemmed tools were exchanged through social networks within a culture area in which distinctive stone mortars and pestles were utilized, and in which animal and plant species and obsidian moved between the eastern Highlands and the Bismarcks (both New Britain and Manus), through the Sepik-Ramu delta, which was at the time an inland sea (Specht, 2005; Swadling & Hide, 2005, pp. 307–308; Torrence & Swadling, 2008, pp. 609–612).

Farther to the west, the people living along the Sepik coast may also have been involved in these regional obsidian exchange networks from an early date. Forty-five of the 456 samples included in this study were previously sourced using PIGME-PIXE by Summerhayes and Torrence. Their analyses showed that obsidian from Talasea (Kutau/Bao) and three Admiralty subsources (Pam Lin, Umrei, and Wekwok) were present at the three archaeological sites represented by the samples examined: Kobom, Ali, and Tarawai Island (Terrell & Welsch, 1997, pp. 561–562; Summerhayes, 2003, pp. 137–138).

Subsequently, all 1,410 obsidian pieces (see Appendix 13.4) collected during the survey phase of the A. B. Lewis Project were analyzed at the Museum by Cecelia Wagner using a relative density technique capable of differentiating between Lou Island and Bismarck obsidian with a high success rate but not between subsources (Green, 1987; Torrence & Victor, 1995; Galipaud & Swete Kelly, 2007). While Admiralty obsidian was dominant at all three Sepik coast sites, Bismarck obsidian was found to be more abundant in contexts suspected to be the oldest, particularly at Kobom. Terrell and Welsch (1997, pp. 562–563) also noted that obsidian flakes from early (i.e., Lapita-era or earlier) contexts are on average larger than those from later contexts, possibly because they were procured through fewer intermediaries, and suggest that the Sepik coast may have been more intensively connected with the Bismarck group during the Lapita period than later. However, the relative density of Pam Island obsidian overlaps with that of the New Britain sources, meaning that some obsidian flakes identified as originating in the Bismarcks may well have actually come from the Pam Lin source (White & Harris, 1997, pp. 103–104).

TABLE 13.4. Obsidian specimens run by p-XRF and LA-ICP-MS.

Locale/sublocale	Total	Method		Associated ceramics	Probable age
		p-XRF	LA-ICP-MS		
Ali Island	**27**	**27**	**14**		
ABLP 622	6	6	1	Lapita	Lapita–contemporary?
ABLP 623	2	2		Lapita	Lapita–contemporary?
ABLP 625	4	4	1	Lapita	Lapita–contemporary?
ABLP 629	3	3	3	Lapita	Lapita–contemporary?
ABLP 630	5	5	4	Lapita	Lapita–contemporary?
ABLP 631	2	2	2	Lapita	Lapita–contemporary?
ABLP 645	5	5	3	Lapita	Lapita–contemporary?
Kobom	**135**	**134**	**20**		
Airati	114	114	9	none	mid-Holocene?
NGRP 25	7	7		none	mid-Holocene?
NGRP 28	3	3		none	mid-Holocene?
NGRP 32	5	5	5	none	mid-Holocene?
NGRP 33	6	5	6	none	mid-Holocene?
Aitape area	**35**	**34**	**9**		
NGRP 9	2	2		Sumalo	1,400–1,200 BP
NGRP 14	1	1		Sumalo	1,400–1,200 BP
NGRP 15	1	1		Sumalo	1,400–1,200 BP
NGRP 16	4	4		Sumalo	1,400–1,200 BP
NGRP 17	6	5	6	Sumalo	1,400–1,200 BP
NGRP 22	2	2		Sumalo	1,400–1,200 BP
NGRP 23	9	9		Sumalo	1,400–1,200 BP
NGRP 24	1	1		Sumalo-Wain	1,400 BP–recent
NGRP 34	1	1		Sumalo-Wain	1,401 BP–recent
NGRP 35	7	7	2	Sumalo-Wain	1,402 BP–recent
NGRP 37	1	1	1	Sumalo-Wain	1,403 BP–recent
Tumleo Island	**80**	**80**	**46**		
NGRP 46 Nyapin levels	23	23	12	Nyapin	2,000–1,500 BP
NGRP 46 Sumalo levels	10	10	7	Sumalo	1,400–1,200 BP
NGRP 46 Aiser levels	25	25	14	Aiser	1,000–500 BP
NGRP 46 Wain levels	10	10	5	Wain	after 500 BP
Surface	12	12	8		unknown
Tarawai Island	**161**	**161**	**6**		
Sareta Recollection	22	22		Lapita derived	~2,000 BP
Sareta Garden Site	23	23	6	Lapita derived	~2,000 BP
Simindibubu	116	116		Lapita derived	~2,000 BP
Total	**438**	**436**	**95**		

Obsidian Analysis

A total of 438 obsidian samples were analyzed by either p-XRF or LA-ICP-MS. In some cases, this includes material analyzed previously by either PIXE-PIGME or the relative density method but also includes excavated material that had not yet been analyzed. Table 13.4 lists the samples by find locale as well as associated ceramics and their probable age.

These samples were surface collected or excavated from 27 individual find spots (Fig. 13.1), but in practice they can be grouped into several larger regional groupings. Twenty-seven surface-collected samples from Ali Island were analyzed, some of which may date to the Lapita period. One hundred thirty-five samples surface collected from a series of find spots near Kobom (Airati, NGRP 25, 28, 32, and 33) may date to the mid-Holocene. Eighty samples were run from stratified contexts at NGRP 46 on Tumleo Island, spanning the entire Nyapin to surface sequence there. While Sumalo Ware is poorly represented in the NGRP 46 sample, 25 samples dating to this time from adjacent mainland find spots (NGRP 9, 14–17, 22, and 23) near Aitape were analyzed. An additional 10 samples were analyzed from find spots in the Aitape area (NGRP 24, 34, 35, and 37) at which Sumalo, Aiser, and Wain ware ceramics were recovered. A total of 161 samples from three find spots on Tandanye (Tarawai) Island (Sareta Recollection, Sareta Garden Site, and Simindibubu) were analyzed. Based on associated ceramics, these three sites are probably contemporaneous with Nyapin material from Tumleo, dating to the first half of the first millennium AD.

Two raw material samples were run alongside the samples. One of these, STMB001, is a small flake taken from a larger block collected at the Kutau/Bao source on the Willaumez peninsula on New Britain. The other, STWW001, comes from a large block collected at the Wekwok source on Lou Island, the same from which ANU2000, run as a standard during previous PIGME-PIXE analyses, was taken.

p-XRF Results

Four chemical compositional profiles were identified among the obsidian specimens measured by p-XRF, and are visible on a bivariate plot of strontium and iron concentrations (Fig. 13.3). The inclusion of raw material samples identifies two of these groups as originating at the Talasea and Lou Island–Wekwok sources, respectively. Comparisons with published data and the PIXE-PIGME analyses of Summerhayes and Torrence confirm

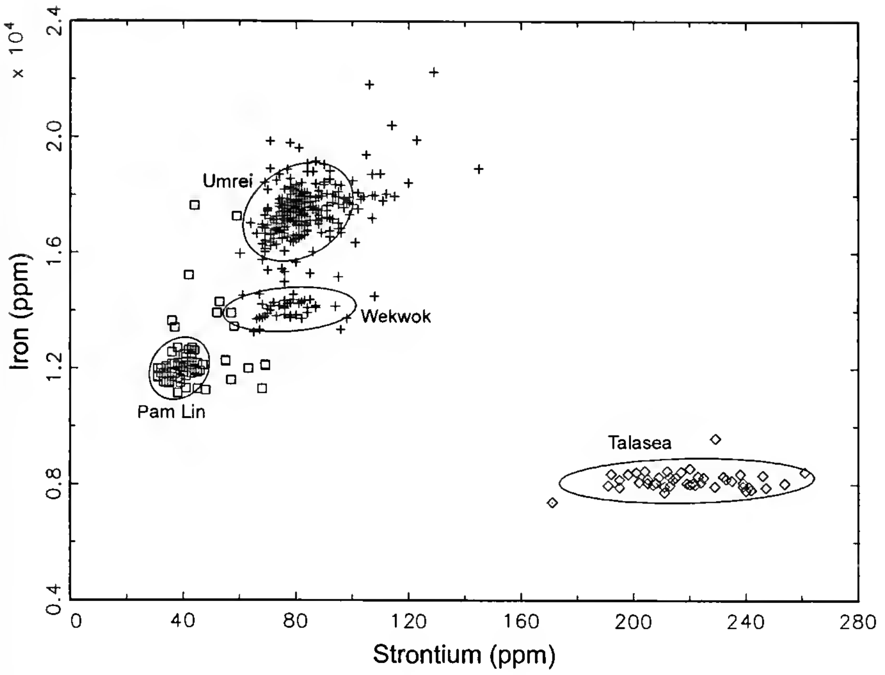

FIG. 13.3. Bivariate strontium-iron plot of p-XRF results showing the separation of all four identified obsidian sources and subsources. Ellipses represent 95% confidence intervals for group membership.

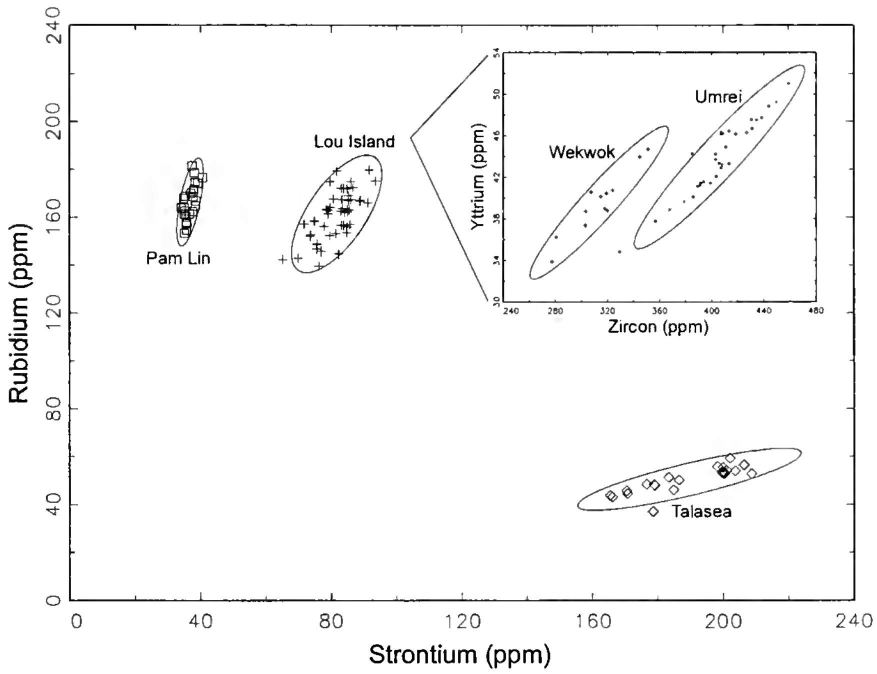

FIG. 13.5. Bivariate plot of strontium and rubidium concentrations measured by LA-ICP-MS showing the three major obsidian sources identified. Ellipses indicate 95% confidence limits for group membership. The inset figure shows chemical separation between the Lou Island Wekwok and Umrei subsources.

the remaining two groups as Pam Lin and Lou Island–Umrei obsidian. However, the small size of many of the obsidian pieces recovered during the A. B. Lewis Project proved problematic. A bivariate plot of Sr and Rb concentrations (Fig. 13.4) shows that while the three major source regions are clearly distinct, the Pam Lin and Lou Island chemical groupings are stretched along both variable axes. The approximate surface areas of a series of samples were subsequently measured. Comparison of surface area to measured concentration of strontium clearly shows that below a size threshold roughly corresponding to the aperture diameter of the instrument, concentrations are overestimated (Fig. 13.4, inset). This effect has been noted previously by Davis et al. (1998), and clearly imposes a size limit on which samples can be successfully characterized by p-XRF. This problem was not apparent in the samples sourced to Kutau/Bao, probably because the pieces of Kutau/Bao obsidian that found their way to the Sepik coast tended on average to be larger than those from the other sources, thus avoiding the issues associated with small surface area.

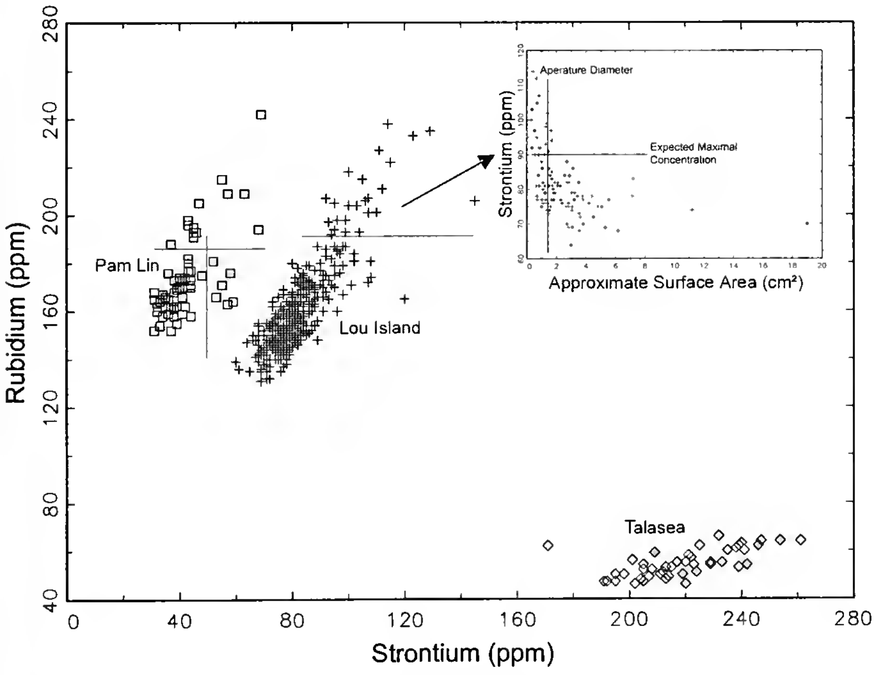

FIG. 13.4. Bivariate plot of strontium and rubidium concentrations for all XRF results. The inset figure shows the effect of small flake size on measured concentrations of strontium.

LA-ICP-MS Results

Subsequently, these small specimens that measured poorly by p-XRF were reanalyzed using LA-ICP-MS. Although all samples assigned to West New Britain were well characterized by p-XRF, a selection of these were also analyzed to test whether additional New Britain subsources might be present. A bivariate plot of Sr and Rb concentrations (Fig. 13.5) shows the division between Pam Lin, Lou Island, and Talasea obsidians. Because LA-ICP-MS measures Fe with poor precision, the Lou Island subsources were resolved using a combination of Zr and Y concentrations (Fig. 13.5, inset). Even with the larger number of elements measured by LA-ICP-MS, there appears to be little internal structure to the "Talasea" group, suggesting that all this material came from a single source flow, most likely Kutau/Mount Bao. The measurement of additional elements also rules out the presence of any Fergusson Island obsidian in the Sepik coast sample. While the Fergusson Faglulu subsource has Zr, Sr, and Rb concentrations that are similar to the Admiralty sources (Ambrose et al., 2009), concentrations of elements such as Nb (averaging 8.10 ppm in the Faglulu subsource) are substantially lower than those measured in any of the Sepik specimens assigned to the Admiralty sources, and higher than values measured in specimens assigned to West New Britain.

By a combination of the two techniques, all 438 specimens were confidently assigned to a source flow. It would seem that p-XRF analysis is entirely adequate for source and subsource determinations for Melanesian obsidian as long as the samples are large enough to adequately cover the X-ray beam. For smaller samples, the microsampling capabilities of LA-ICP-MS clearly provide a better means of characterization. In the future, LA-ICP-MS need only be used for these very small samples, and the cheaper and more rapid analysis capable with p-XRF is clearly desirable for larger pieces. For a summation of chemical group averages for obsidian sources determined by both methods, see Appendix 13.1.

Ceramic Analyses

In general, measured chemical variability in ceramics may be the result of one or a combination of four factors: parent geological variability of utilized clays, tempering or clay mixing, use, and post-depositional alteration (Neff et al., 2003, p. 202). Assessing the potential for differentiating ceramics in a region, therefore, begins by assessing the geological variability present in the study region, though it should be noted that chemical gradients within geologically homogeneous regions have been observed to exist in other studies (Neff et al., 2000, p. 314; Cochrane & Neff, 2006, p. 383).

Geology of the Sepik Coast

New Guinea consists of a southern portion of continental affinity, and a northern section comprised of a variety of oceanic terranes. These combined during the collision of the northern margin of the Australian craton with island arcs along the southern boundary of the Pacific plate between the Eocene (eastern PNG) and late Oligocene/early Miocene (western PNG), leading to the formation of the central highlands/mobile belt as well as lesser northern (Bewani/Torricelli, Prince Alexander, and Finisterre) ranges (Dow, 1977, pp. 6–11; Pigram & Davies, 1987, pp. 193–194).

The area reported on here comprises the foothills and floodplains to the north of the Torricelli/Bewani Mountains. The mountains and associated foothills consist primarily of two complexes formed as part of calcalkaline and tholeiitic island arcs: the Bliri Volcanics (a mixed sequence of mainly basaltic and andesitic lavas and associated volcanoclastic rocks, minor argillite, limestone, bedded radiolarian chert, and tuffaceous limestone of late Cretaceous age) and the Torricelli Intrusive Complex (medium grained, nonporphyritic gabbro and diorite, dolerite, subordinate monzonite and granodiorite, rare adamellite, harzburgite, and pyroxenite dating partially to the late Cretaceous and partially to the early Miocene). The floodplains consist of outwash detritus from these, and date to the Neogene and Quaternary (Norvick & Hutchison, 1980, pp. 1, 7, 33; Pigram & Davies, 1987, p. 209) as well as former lagoons that are today infilled with clays (Terrell & Welsch, 1997, p. 565). These lagoonal clays are not ethnographically documented as having been used for potting but could have been prehistorically.

In the western portion of the study area, the villages of Leitre and Serra are located at the foot of the Serra Hills, which consist of limestone and a variety of siltstones, mudstones, marl, and sandstone (Marchant, 1969, p. 15; Norvick & Hutchison, 1980, table 2). The region near Aitape consists of tuffaceous limestone ridges associated with the Bliri volcanics that have been connected to the mainland by progradation of the floodplains. Tumleo, Angel, Seleo, and Ali are coral islands (Terrell & Welsch, 1997, p. 565), though Tumleo differs from Angel and Seleo in that there is an outcropping of tuffaceous limestone at the northwestern corner of the island (Haantjens, 1972, pp. 50, 57, 180, 230; Norvick & Hutchison, 1980, table 1), from which potting clay can be obtained (Parkinson, 1900, p. 38; Terrell, pers. comm.). Although a complex geological environment, the Sepik coast presents a degree of patterned geological variability that could result in pots produced in differing locales being chemically distinct from one another.

Sample

Three hundred twenty-six ceramic and clay samples were analyzed by LA-ICP-MS from the 15 locales described in Chapter 5 (Fig. 13.1). The majority of the samples were selected from a total of 10,739 sherds from 121 find spots collected by Terrell and Welsch during 1993 and 1994, while a number of pots were analyzed from the Field Museum Pacific collections (Table 13.5). During an initial pilot study, all 50 sherds analyzed by Dickinson in thin section (Chapter 12) were analyzed by LA-ICP-MS. As these results indicated patterned chemical variability by both locale and to a lesser degree by temper group, a broader set of ceramics was selected for further analysis.

The remaining samples were preferentially selected on the basis of the presence of diagnostic decorations or other stylistic features that gave some indication as to their age, but only in the case of site NGRP 46 was it possible to randomly sample from secure stratified contexts. In most cases, the sample analyzed simply represented all ceramics collected from a particular locale that had been sampled in 1993 in the field for illustration and publication.

The total sample is not exhaustive of all known production centers in the study region. Further potting villages exist at Vanimo in the west and near Wewak in the east. Furthermore, people in the study area are reported ethnographically to have received pots occasionally from as far away as Humboldt Bay and Lake Sentani (Indonesia) as well as from villages in the Torricelli and Prince Alexander Mountains (May & Tuckson, 1982, pp. 301–302, 317–325).

Ceramic samples were also analyzed from three regions beyond the Sepik coast for comparison with Sepik ceramics. Pots from Manus (Admiralty Group) and West New Britain were included in order to explore whether the single Lapita sherd found on Ali Island is chemically similar or dissimilar to ceramics from nearby regions where Lapita sites have been discovered. Nine sherds from Wanigela (Collingswood Bay) were included as a further comparison.

Leitre—All the 14 samples from Leitre were surface collected, and came from two localities: Isi and Nowage. While of uncertain age, there is nothing to suggest that these sherds are older than a few hundred years. Two ethnographically collected clays were also analyzed. One, LT343, was taken directly from a source in the Serra Hills behind the village of Nowage, while the other, LT3456, derives from the same source but was tempered with sand by a local potter in anticipation of its use in pottery manufacture.

Serra—A total of 29 samples were analyzed from near Serra, one of which was recovered near Serai and is presumed of recent or protohistorical manufacture. The others are from Rainuk 606 (10), 608 (1), and 609 (11). These are believed to be successively occupied villages. Individual sherds collected from Rainuk 606 and 608 are unequivocally of Wain Ware, suggesting that the other ceramics also date to roughly this time. Based on stylistic criteria, Rainuk 609 may be slightly earlier than 606 and 608. Five clays were also analyzed, all from sources that either are currently utilized by potters or were in the recent past. Clay sample SR189 derives from a source near Puindu Hamlet. Samples SR190A–C were collected from a recently utilized source near Peitol, while clay SR191 comes from a new source (Aitape Long) also near Peitol.

TABLE 13.5. Ceramic samples analyzed by ICP-MS, by find locale grouped by chronological association and temper group as defined by Dickinson (Chapter 12).

Locale/sublocale	Chronological context									Temper group							
	Lapita	Nyapin	Sumalo	Aiser	Wain	Modern	Unknown	Clays	Total	A	B	C	D	E	F	G	Outlier
Leitre									**14**	2		1					1
Isi							7			1		1					
Nowage Village							5	2		1							1
Serra									**29**	1	3	1					
Rainuk 606							10				1	1					
Rainuk 608					1		1										
Rainuk 609							11				2						
Serai							1			1							
Aitape Long								1									
Puindu								1									
Peitol								3									
Ramu Village							8		**8**				1	1			
Aitape									**43**							5	
Sumalo Hill			15													2	
NGRP 16			16													1	
NGRP 23			12													2	
Tumleo Island									**113**					5	1	1	
Ethnographic Collection						2											
Ainamul Hamlet							2							1	1		
Wain Locality					7									1			
Nyapin			1	9	10												
NGRP 46		10	24	28	17									3		1	
Nuwaic Hill, Aitape								1									
Pai Rainu Camp								1									
Little Mountain								1		2							
Ali Island									**2**	1							
La'ai							1			1							
Tubungbale Area A	1																
Wom/Aiser				27					**27**			1	1	2			
Walis Island									**22**			4	1	1		1	
Lakeba							5					2					
Buamunding							15					1		1		1	
Kambilal Hamlet							2					1	1				
Tarawai Island									**37**		2	2	1	1	1	7	
Munchika School Area 2					15							1				1	
Munchika New Garden Area A				7												2	
Munchika New Garden Area B							2					1				1	
Simindibubu		6									1					1	
Tawatohui							2							1		1	
Sareta		3									1		1				
Tarawai Village							2								1	1	
Kaiep						1	6		**7**	1							
Wanigela (Collingswood Bay)						9			**9**								
Manus Island						1			**1**								
New Britain									**4**								
Solong						2											
Cape Merkus						2											
Total	**1**	**19**	**68**	**71**	**50**	**17**	**80**	**10**	**316**	5	5	9	4	10	2	14	1

RAMU VILLAGE—All eight samples from Ramu were surface collected, and are of unknown but presumed recent age. No clay samples were available for analysis, although a potting industry existed there in the early 20th century (May & Tuckson, 1982, p. 316), and Terrell and Welsch (Terrell, pers. comm.) were told in 1993 at Ramu that women there still knew how to make pots.

TUMLEO ISLAND—The 113 sherds analyzed from contexts on Tumleo Island include 10 Nyapin Ware sherds, 24 Sumalo Ware sherds, 28 Aiser Ware sherds, and 17 Wain Ware sherds from NGRP 46. Two samples from Ainamul Hamlet are believed to be premodern but post-Wain stylistically, while additional samples from Nyapin and Wain localities belong to the Sumalo, Aiser, and Wain wares. In addition, two ethnographically collected pots were analyzed, both of which were produced by modern Tumleo potters.

Four clays collected from Tumleo potters were also analyzed. One of these, TM167, is *paic nuwaic* (black clay) collected by Welsch and Terrell from the "Little Mountain" source on Tumleo itself (the outcropping of the Bliri volcanics at the northwestern corner of the island mentioned above), and is presumably similar to the clay Parkinson observed in use during the early 20th century, which he described as having weathered from crystalline limestone. TM165 is *paic nuwaic* clay obtained from St. Mary's at Aitape. TM166 is *paic pai* "red clay" obtained at Raihu hamlet on the mainland. TM164, *paic trarun* clay, true to its description as "like flour," proved impossible to fire into a briquette, and crumbled into dust soon after being removed from the kiln. However, a fourth clay briquette, TM456, was mixed by the author using clays TM164–166. It was hoped that this would simulate ethnographically observed practices of clay mixing still followed on Tumleo (Tuckson, 1977, pp. 76–77; May & Tuckson, 1982, pp. 308, 310, 314). Erdweg (1902, p. 350) describes all these types of clay as being available from different parts of the "Little Mountain" outcrop, though modern potters say that *paic pai* is available only on the mainland (May & Tuckson, 1982, p. 310).

Aitape—The 43 sherds analyzed from Aitape derived from NGRP 16, NGRP 23, and Sumalo Hill, all dated securely to the time when Sumalo Ware was in fashion. Sherds from NGRP 22 were avoided because of the intense chemical weathering observed there (Chapters 5 and 6). Today, Tumleo Island potters have settled at Yakoi and Raihu hamlets (May & Tuckson, 1982, pp. 301, 308; Terrell, pers. comm.). Clays TM165–166 and 465 described above represent potential mainland clay sources utilized by ancient Aitape potters. In 1990, Tumleo potters living at Yakoi mentioned several sources to Welsch and Terrell, including a hill north of Aitape called "Kapalabar," where a red clay was obtained, and two sources farther west along the coast where *trarun* and *nuwaic* type clays can be obtained. All three sources appear to be associated with Miocene/Pliocene limestone ridges.

Ali Island—The Ali sample consists of only two sherds; one of Lapita style from the locality on the island named Tubungbale (Fig. 13.6); the other, which is visually similar to some of the potsherds collected at Serra and Leitre near the Indonesian border, came from a hamlet area called La'ai. As a side note, Ali Island is comprised entirely of a raised coral platform and lime sands, and there is no local clay source on the island (Haantjens, 1972, pp. 50, 180).

Wom/Aiser—"Wom" and "Aiser" are local names for two nearby collecting localities on the mainland (see Chapter 5) where sherds of the distinctive ware we now refer to as "Aiser" were found by a local farmer and first brought to the attention of Welsch and Terrell in 1993, who subsequently visited both localities. The 27 samples analyzed from Wom are all stylistically Aiser Ware (as defined in this monograph; see Chapter 7), but there is enough variation between the Wom specimens and Aiser Ware sherds from Tumleo Island both stylistically and in terms of the visual appearance of the ceramic paste to suggest that these may come from a different production center located presumably on the mainland. The closest modern industries are those at Yakoi and Raihu. No clays from sources close to Wom/Aiser were available for analysis.

Tarawai Island—There is no modern potting industry on Tarawai Island (Tandanye), which currently gets its pottery from a number of locations on the coast. The 38 specimens from this island included in this study were recovered from localities designated in 1993 as Munchika School Area 2 and New Garden Areas A and B, Simindibubu, Tawatohui, Sareta, and Tarawai Village (see Fig. 5.17). On present

Fig. 13.6. Lapita-style potsherd recovered at Tubungbale on Ali Island.

evidence, it seems likely that the Tarawai Village sherds are quite recent in age. Two specimens from Munchika School Area 2 are in the style of Wain Ware, and may therefore date the rest of the material from this locality to that later prehistoric period. Much of the rest of the School Area 2 material closely resembles Kaiep pottery stylistically, and may have originated there. Tawatohui is a collecting locality near Munchika, but it is unclear if material from there dates to the same time period. A single specimen from New Garden Area A is of Aiser Ware, while the rest of the material from there closely resembles "Type X" pottery—a ceramic style identified by Specht and others at mainland sites in the eastern Sepik coast region. Specht and his colleagues suspect that Type X comes from a production center located somewhere on the Huon peninsula (Specht et al., 2006, pp. 40–41). Type X was probably being made there from ~1,000 BP to ~500 BP (Lilley & Specht, 2007, p. 224), which would be in keeping with the likely Aiser Ware age for New Garden Area A. The rest of the analyzed samples are of uncertain age, though ceramics from the interior localities called Simindibubu and Sareta are suspected to be contemporaneous with Nyapin Ware in the Aitape area based on their stylistic similarities both to that ware and to Lapita style ceramics elsewhere in the Pacific.

Walis Island—Twenty-one samples were taken from three localities locally called Lakeba (5), Buamunding (14), and Kambilal Hamlet (2). These samples are of unknown age. Many of the samples from Buamunding are in an unusual style characterized by deep channeled impressions. There is no modern industry on the island, and no clays were available for this analysis. Both Walis and Tarawai islands consist principally of coral and coral sand, suggesting that clay may not be readily available on either island.

KAIEP (KEP) VILLAGE—Seven samples were analyzed from Kaiep (Kep) Village on the coast east of Wewak. Three samples, KP001, 003, and 200, were analyzed using the regular laser chamber. One of these, KP200, was surface collected at Kaiep during the A. B. Lewis Project, and is consistent stylistically with what is produced there today. The remainder, KP004–007, were whole pots that could not be broken, and were analyzed with the adaptable laser chamber. Modern potters at Kaiep and the nearby village of Terebu obtain clays from a number of sources near the village (Allen, 1977, p. 72; May & Tuckson, 1982, pp. 302–304, 307); no clay samples, however, were available for analysis.

WANIGELA—Nine samples at the Museum from Wanigela (Collingswood Bay) collected before World War I by A. B. Lewis were analyzed, principally to serve as an out-group from a geologically distinct region with which to compare with the Sepik coast sample. Wanigela is located on Cape Nelson on the beach at the foot of Mount Trafalgar and Mount Victory, both Pleistocene and Holocene volcanoes consisting of andecite, basalt, and dacite of high-potassium calc-alkaline association (Davies, 1971, pl. 1; Smith & Davies, 1976, pp. 46–48).

MANUS ISLAND—A single pot at the Museum collected ethnographieally on Manus Island in the Admiralty archipelago was analyzed using the adaptable laser chamber. Its exact provenience is unknown.

NEW BRITAIN—The Huon peninsula comprises primarily the Finisterre terrane and associated detrital material consisting of Oligocene to early Miocene basaltic to andesitic volcanic rocks with high potash, high alumina basaltic, and shoshonitic affinities. These are overlain by shallow-water limestones of middle Miocene to Pliocene age (Pigram & Davies, 1987, pp. 202, 210). People living on New Britain are ethnographically documented as having received their pottery from production centers along the Huon peninsula, where pottery making has been documented at the villages of Sio, Nambariwa, and Gitua on the Kunai coast, Yabob and Bilibili Islands (Astrolabe Bay), Mindiri on the western edge of the Rai coast, and villages along the southern edge of the Huon peninsula—this is collectively referred to as "Madang" pottery (May & Tuckson, 1982, pp. 149–151; Lilley, 1986, pp. 67–70). Four whole pots from New Britain were analyzed using the adaptable laser chamber. All four were collected on Cape Merkus—two at Arawe, and two at Solong. Pottery production on New Britain is believed to have ceased in the post-Lapita period, and these pots were likely obtained by exchange, probably from Siassi or Bilibili traders.

Results

A number of distinct chemical groupings were recognized within the ceramic data at a variety of geographical scales. At a broad geographical scale, ceramic sherds recovered on the Sepik coast are chemically distinct from pottery recovered at Wanigela as well as pots from Manus and New Britain. At a more local scale, the Sepik coast ceramics can be divided into five chemical reference groups: one associated principally with

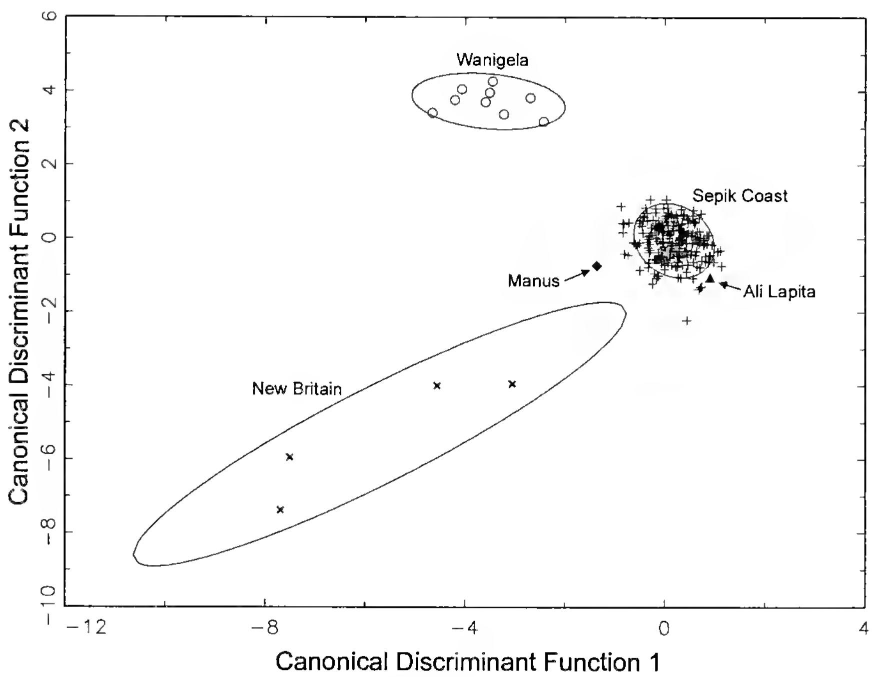

FIG. 13.7. Canonical linear discriminant function results showing chemical differentiation between Sepik coast ceramics, Wanigela ceramics, and Bismarck Archipelago ceramics. Ellipses represent 90% confidence limits for group membership.

ceramics from the Serra Hills (Leitre and Serra), two with ceramics from Tumleo Island and Wom/Aiser, one with ceramics near the modern town of Aitape, and one comprised of decorated sherds recovered at the Buamunding locality on Walis Island. These five are referred to here as chemical *reference groups* because each of them comprises a sufficient number of specimens to compare unassigned sherds statistically to them. Sherds recovered from Ramu and Kaiep also cluster in multivariate chemical space, but in both cases there are not enough measured sherds to statistically compare unassigned specimens to these evident clusters. As such, the Ramu and Kaiep sherds are referred to hereafter as *chemical groups*, not chemical *reference groups*. For a complete listing of group average chemical concentrations, see Appendix 13.2. For jackknifed Mahalanobis distance based group membership probabilities relative to the five chemical *reference* groups, see Appendix 13.3.

Comparison of Sepik Coast Sherds to Those from Other Areas of Melanesia

Initial exploratory data analysis suggested that three macroscale chemical groups could be constructed, one comprising the entire set of ceramics collected on the Sepik coast, a second consisting of the nine sherds from Wanigela, and a third containing the ceramics tested from New Britain. The single pot analyzed from Manus does not fall into any of these three chemical groups, suggesting that if more Manus pottery were analyzed, a fourth chemical group could be constructed comprising Manus Island ceramics.

Unlike those in the Sepik coast group, sherds from Wanigela are considerably enriched in Ba, Pb, and Th and depleted in V and Co. Those from Cape Merkus are enriched in B, Ca, K, Mg, and Pb and depleted in Al, Nb, Th, and U relative to Sepik coast sherds. This pottery is also chemically diverse. It is possible that two or more production locations are represented—however, the chemical signature for the Huon peninsula as a whole appears differentiable from that of the Sepik coast.

The single pot from Manus is enriched in Ca and depleted in Fe, Mn, Cs, and rare earth concentrations relative to Sepik

TABLE 13.6. Group membership probabilities for non-Sepik coast sherds and the Ali Island Lapita sherd relative to the combined Sepik coast ceramic group.

Context and specimen	Membership probability
Ali Lapita	
ALI641	0.223
Manus Island	
BA003	0.000
New Britain	
BA001	0.000
BA002	0.000
BA005	0.000
BA006	0.000
Wanigela	
WN001	0.000
WN002	0.000
WN003	0.000
WN004	0.000
WN005	0.110
WN006	0.000
WN007	0.000
WN008	0.000
WN009	0.000

coast sherds. A canonical discriminant function analysis shows this separation (Fig. 13.7), and calculation of group membership probabilities for the Wanigela, New Britain, and Manus sherds relative to the combined Sepik coast chemical reference group further confirms that these pots are chemically distinct in multivariate space (Table 13.6).

The Ali Island Lapita Sherd

Although the present sample omits large areas of island Melanesia, it nonetheless provides a means of addressing the origins of the early Lapita sherd recovered on Ali Island. Was this sherd produced locally, or was it brought in from somewhere else, perhaps from a production center in the Bismarck or Admiralty groups, where the nearest known Lapita sites are located (Gosden et al., 1989)?

In Figure 13.7, the Ali Lapita sherd falls outside of the 90% confidence ellipses for all the other analyzed ceramics, though it is most similar to the Sepik coast pottery. However, the Ali sherd has an insignificant probability of membership in the combined Sepik coast chemical reference group (Table 13.6), principally because the Ali sherd has lower concentrations of Al, Na, and Mn than the remainder of the sherds recovered from sites on the Sepik coast. It should be noted that a number of analyzed specimens belonging to wares local to the Sepik coast are also statistical outliers of the general Sepik coast chemical group, and fall just outside of the 90% confidence ellipse on Figure 13.7 as well.

The small number of specimens from New Britain and Manus makes it impossible at present to compare the Ali sherd statistically to them, but the CDA results do not suggest that the Ali sherd can be linked to either the Huon peninsula or Manus. Unfortunately, other trace element studies of ceramics and raw materials from island Melanesia—for instance, Hunt's (1989, p. 172, app. C) analysis (using SEM-EDX) of clays from the Admiralty group and MD-ICP-MS analysis of Lapita sherds from Kamgot on New Ireland by Kennet et al. (2004, p. 42)—are of little use, as these studies utilized different analytical techniques, and in the case of the Kennet study, analyzed both clay and temper fractions of Lapita ceramic sherds.

At present, the origin of the Tubungbale Lapita sherd remains ambiguous. Although not statistically assignable to the Sepik coast chemical profile, it is possible that this Lapita sherd represents a statistical outlier of Sepik production or was produced from a variant paste recipe that was no longer used later during Sepik prehistory. Alternatively, the Tubungbale Lapita sherd may have been produced farther east in the Bismarcks from clays that are geochemically similar to those present on the Sepik coast.

Sepik Coast Ceramics

As a preliminary means of examining multivariate patterning within the Sepik coast ceramics, R-Q mode factor analysis was performed on the variance–covariance matrix. In conjunction with inspection of bivariate plots, this analysis suggested clustering on a site-by-site basis. However, closer inspection revealed that only elevated Ba concentrations differentiate Wom/Aiser specimens from other ceramics from the western end of the study area. Wom/Aiser sherds average 835 ppm, while no other ceramics from the Sepik coast exceed ~300 ppm (Fig. 13.12). While high Ba concentrations could conceivably be characteristic of raw materials available in the vicinity of Wom, the fact that only Wom/Aiser sherds display high Ba concentrations, that all Wom/Aiser sherds have high Ba concentrations, and that only a single element, and one that is known to be particularly mobile in groundwater, distinguishes these samples from all others raised suspicions that postburial leaching may have contributed to the observed Ba concentrations in these sherds. A separate project carried out using time-of-flight ICP-MS at the Institute for Integrative Research in Materials, Environments, and Societies at California State University, Long Beach, indicates that this is very likely the case. Three low-Ba samples (one from Tumleo, one from Leitre, and one from Aitape) were elementally mapped in cross section, as were three high-Ba Wom/Aiser samples. Only the Wom samples displayed sharp gradients in concentration from inside to outside or strong concentrations of Ba along vessel walls characteristic of leaching (Golitko et al., 2007, p. 17). Therefore, Ba was removed from consideration, and a second R-Q mode factor analysis performed. All further statistical calculations were performed on the basis of this second R-Q mode analysis, using the first 12 components, which account for ~90% of the total variance in the dataset.

A plot of the first and second principal components (Fig. 13.8), which account for 40% and 14% of the total data variance, respectively, reveals that although not entirely distinct, ceramics recovered at each separate locality generally cluster together. The rare earth elements are heavily loaded positively on PC1, and Si is heavily loaded negatively. This seems to express a roughly east–west trend in the data, with most eastern Sepik pottery (from Walis, Tarawai, and Kaiep) scoring low on PC1, and ceramics from western Sepik locales (Ali, Tumleo, Aitape, Wom, Ramu, Serra, and Leitre) scoring higher on PC1. PC2 expresses primarily elemental variation that separates between the locales on western end of the Sepik coast—Serra and Leitre ceramics score high on PC2, and are enriched in a suite of elements, including Li, Cr, and Bi, and depleted in a suite of elements, including primarily Ca, Cu, Sr,

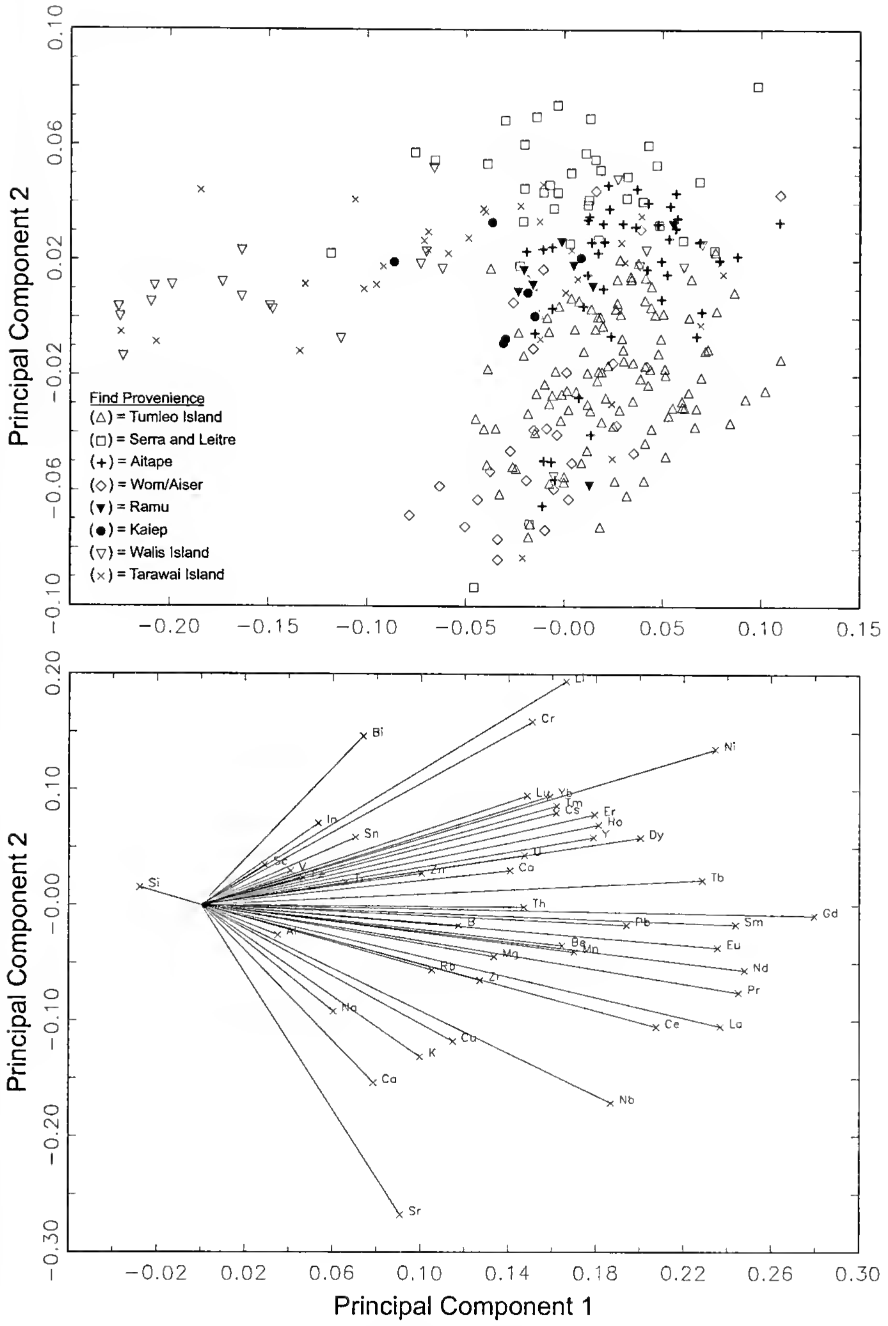

FIG. 13.8. Biplot of first two principal components calculated for the Sepik coast ceramic sample. Sherds are labeled by find location, not by final chemical group assignment.

and Nb. Wom/Aiser and Tumleo Island ceramics score low on PC2, and hence display an opposite pattern of enrichment and dilution. Aitape and Ramu ceramics appear to be chemically intermediate between these two extremes. Clustering by find locale on the first two principal components suggests that each locale might have a unique chemical signature. The principal components plot also indicates that there are a number of sherds in the sample that potentially were exchanged. For instance, several sherds recovered at Aitape score low on PC2 and therefore overlap with the bulk of the ceramics from the Wom/Aiser and Tumleo Island sites, as does a single sherd from Ramu and at least two sherds from Serra. Some sherds from Walis Island also appear to overlap with either Aitape or Serra/Leitre ceramics. The sherds from Tarawai Island are widely distributed on the PCA plot, with little indication of any points of high density. This suggests that the Tarawai sherds may derive from a variety of production locations.

Western Sepik Coastal Ceramics

The majority of sherds analyzed from sites toward the western end of the Sepik coast (Serra, Leitre, Ramu, Aitape, Wom/Aiser, Tumleo, and Ali) could be assigned to one of the four defined western chemical reference groups, labeled the Serra Hills and Aitape-Barida 1–3 reference groups. A number of unassignable sherds hint at acquisition of ceramics from elsewhere, too. However, this number (13) represents only a small fraction (~6%) of the 236 sherds analyzed from western Sepik sites. Some of these are, in all probability, statistical outliers of the identified chemical groups, though a handful of sherds are divergent enough chemically to suspect that they were acquired from farther afield. Seven sherds were identified that have high probabilities of membership in more than one of the four western Sepik coast reference groups, and could therefore not be confidently assigned to a group. In addition, the majority of the sherds analyzed from Ramu, though overlapping statistically with the Serra Hills and Aitape-Barida 3 chemical reference groups, can be differentiated on bivariate elemental plots, suggesting a unique chemical signature associated with production there.

SERRA HILLS AND AITAPE-BARIDA REFERENCE GROUP CERAMICS—As indicated by the principal components plot (Fig. 13.8), the majority of ceramics recovered at sites near Leitre and Serra are chemically distinct from other western Sepik ceramics, having in general lower concentrations of Ca, Cu, Sr, and Nb, and enriched concentrations of Li and Cs. Only a handful of sherds from Serra and Leitre sites cannot be associated with this reference group, for instance, sherd SR6069, a Wain sherd probably made on or near Tumleo Island. The remaining western Sepik sherds were grouped into three "Aitape-Barida" reference groups. These groups are so named because modern potters in this area utilize clays derived from the tuffaceous limestone ridges associated with the Aitape and Barida land systems as defined in Haanjtens (1972), and the chemistry of pottery in these three reference groups appears consistent with measured clay samples obtained from Tumleo potters and known to have been obtained from Aitape and Barida land system formations.

The Aitape-Barida 1 reference group includes Aiser Ware sherds from Wom as well as Wain and Aiser Ware material from the Wain and Nyapin localities on Tumleo Island. The Aitape-Barida 2 reference group includes primarily ceramics recovered during excavations at NGRP 46 on Tumleo, spanning the entire Nyapin-Wain sequence both stylistically and chronologically. The Aitape-Barida 3 reference group consists principally of ceramics recovered at Sumalo Hill, NGRP 16, and NGRP 23 on the mainland near the modern town of Aitape.

A bivariate Sr-Ca plot (Fig. 13.9) shows the chemical differentiation between the Serra Hills, Aitape-Barida 3, and Aitape-Barida 1 and 2 chemical groups, which overlap on this particular projection of the data. The high Ca concentrations in ceramics belonging to the three Aitape-Barida reference groups are consistent with a derivation from clays weathered from limestone ridges, and those in the clays obtained from Tumleo potters indeed do have higher average calcium values than those obtained from Serra Hills sources. The exceptions to this are the raw clay, LT343CL, from Leitre and one of the Serra clays, SR189CL, both of which appear to overlap with the Aitape-Barida 3 reference group on this projection of the data.

A bivariate Sn-Ce plot (Fig. 13.10) shows the distinction between the Aitape-Barida 1 and 2 reference groups. In contrast to the Aitape-Barida 1 group, pottery in the Aitape-Barida 2 group is generally enriched in a series of transition and poor metals, including Fe, Cu, Zn, Ni, Sn, In, Bi, and Pb. Additionally, Aitape-Barida 2 pottery is Al rich and Si poor

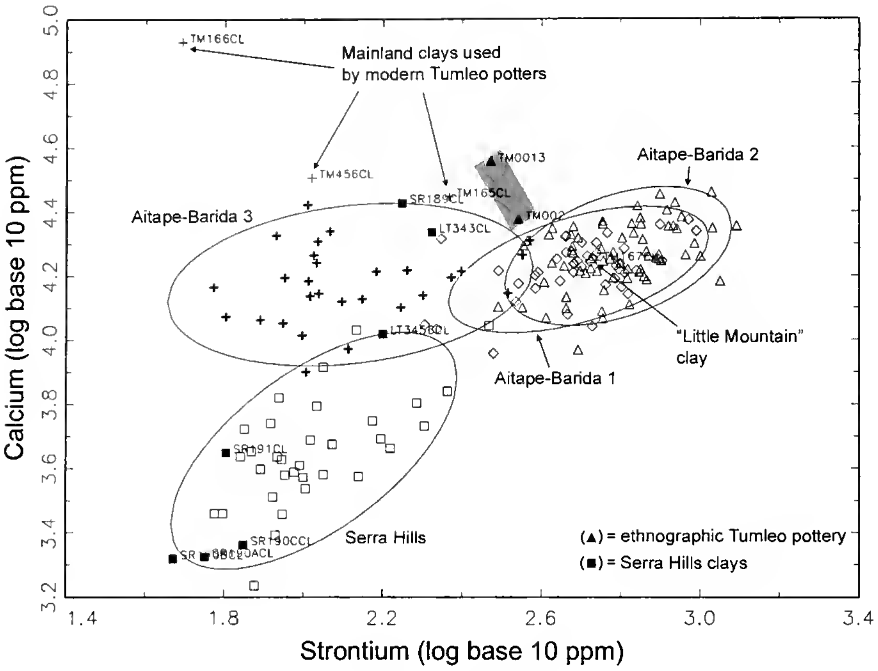

FIG. 13.9. Bivariate plot of logged strontium and calcium concentrations showing distinction between Serra Hills, Aitape-Barida 3, and Aitape-Barida 1 and 2 chemical reference groups. Ethnographically collected modern pottery produced on Tumleo and clay samples from the Serra Hills and Tumleo are also shown. Ellipses represent 90% confidence limits for group membership.

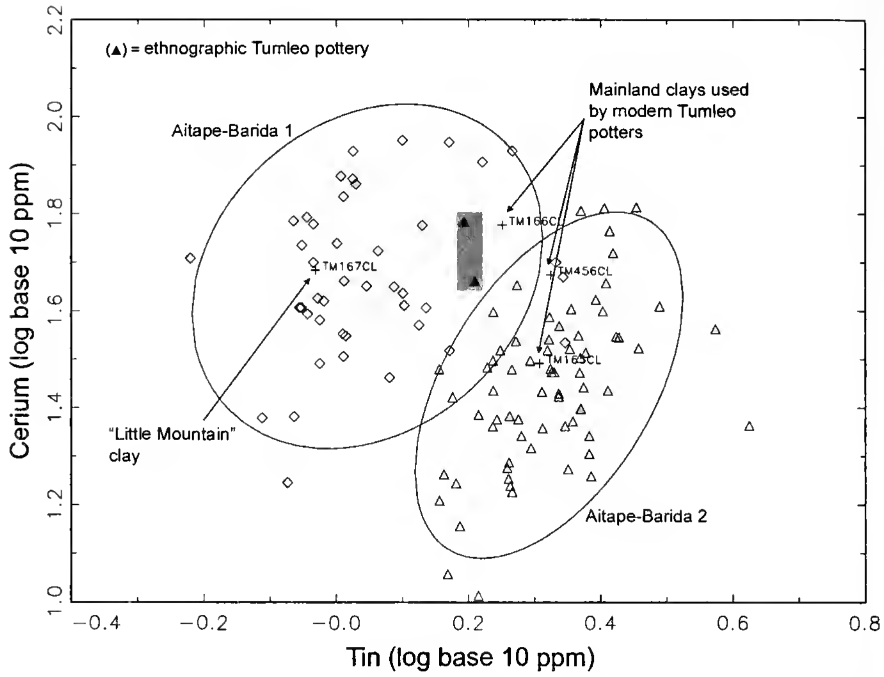

FIG. 13.10. Bivariate plot of logged tin and cerium concentrations showing distinction between Aitape-Barida 1 and 2 reference groups. Ethnographically collected modern pottery produced on Tumleo and clay samples collected from modern Tumleo potters are also shown. Ellipses represent 90% confidence limits for group membership.

relative to Aitape-Barida 1 ceramics and displays a somewhat different pattern of rare earth element concentrations.

Calculation of membership probabilities for clay samples relative to the defined reference groups provides some suggestion as to the geographical interpretation of the sherd chemistry (Table 13.7). In general, the Serra Hills clays, particularly those from the Peitol sources, are excellent matches for ceramics in the Serra Hills reference group. The remaining Serra clay, SR189CL, as well as the raw clay from Leitre have higher probabilities of membership in the Aitape-Barida 1 reference group, but in bivariate projections both have many of the basic chemical characteristics of the Serra Hills reference group ceramics, with the exception of elevated Ca concentrations. These clays probably have a more significant contribution from the late Pliocene limestones that are present in the Serra Hills. The prepared clay from Leitre, LT3456CL, though still having a reasonable probability of belonging to the Aitape-Barida 1 reference group, is more statistically similar to the Serra Hills reference group ceramics. Modern potters describe the clays available near the coast at Leitre as being inferior to those obtained from sources in the mountains such as Peitol (May & Tuckson, 1982, p. 16), and it is possible that prehistoric potters more commonly used mountain sources. Inspection of bivariate plots shows that the same elements that differentiate the Serra Hills reference group from the three Aitape-Barida reference groups also separate the Serra Hills clays from the clays utilized by Tumleo Islanders, for instance Cu and Ca (Fig. 13.11). This finding evidently expresses a difference in the basic geological origin of these clays, with Serra and Leitre clays weathered from the silt, mudstones, and late Pliocene limestones of the Serra Hills, and clays utilized by Tumleo potters coming from the Miocene/early Pliocene tuffaceous limestone ridges characteristic of the Aitape area. As such, it seems likely, both

TABLE 13.7. Membership probabilities relative to the identified chemical reference groups for all analyzed clay samples.

	Group membership probabilities				
Collection spot and specimen	**Serra Hills reference**	**Aitape-Barida 1 reference**	**Aitape-Barida 2 reference**	**Aitape-Barida 3 reference**	**Buamunding reference[a]**
Leitre clays					
LT343CL	0.332	0.600	0.008	0.092	0.045
LT3456CL	7.309	7.085	0.013	0.702	0.037
Serra clays					
SR189CL	2.753	27.113	0.004	3.184	0.039
SR190ACL	20.691	0.000	0.000	0.000	0.077
SR190BCL	55.865	0.000	0.000	0.001	0.073
SR190CCL	80.236	0.000	0.000	0.054	0.080
SR191CL	93.669	0.000	0.000	0.001	0.047
Tumleo clays					
TM165CL	0.016	11.675	0.001	0.003	0.020
TM166CL	0.000	0.000	0.000	0.110	0.016
TM456CL	0.043	0.109	0.000	0.081	0.019
TM167CL	0.002	84.333	0.160	0.493	0.017

[a] Calculated from first 10 principal components.

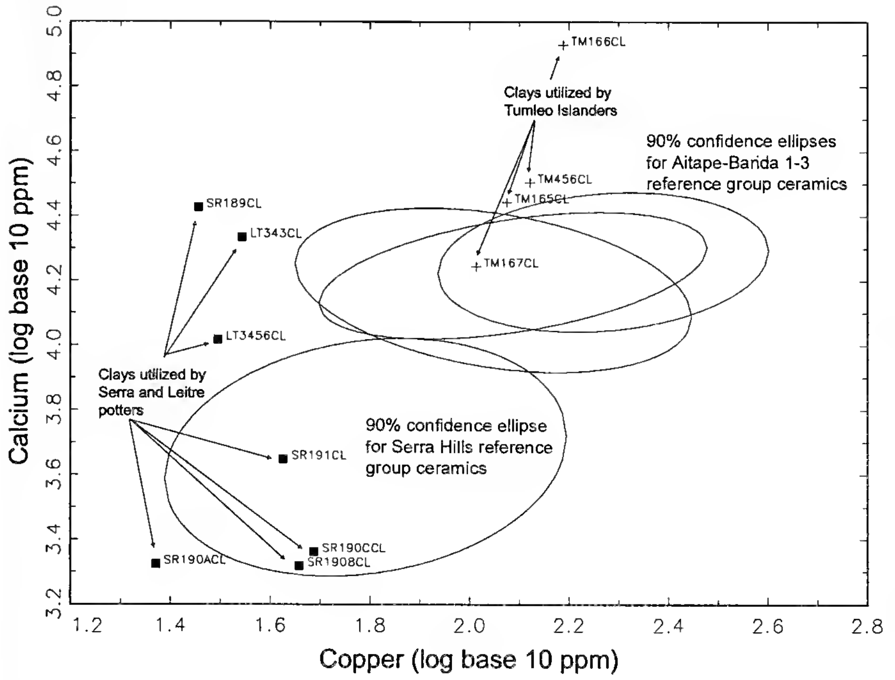

FIG. 13.11. Bivariate plot of logged copper and calcium concentrations showing clay samples projected against the 90% confidence ellipses for the Serra Hills and Aitape-Barida 1, 2, and 3 chemical reference groups.

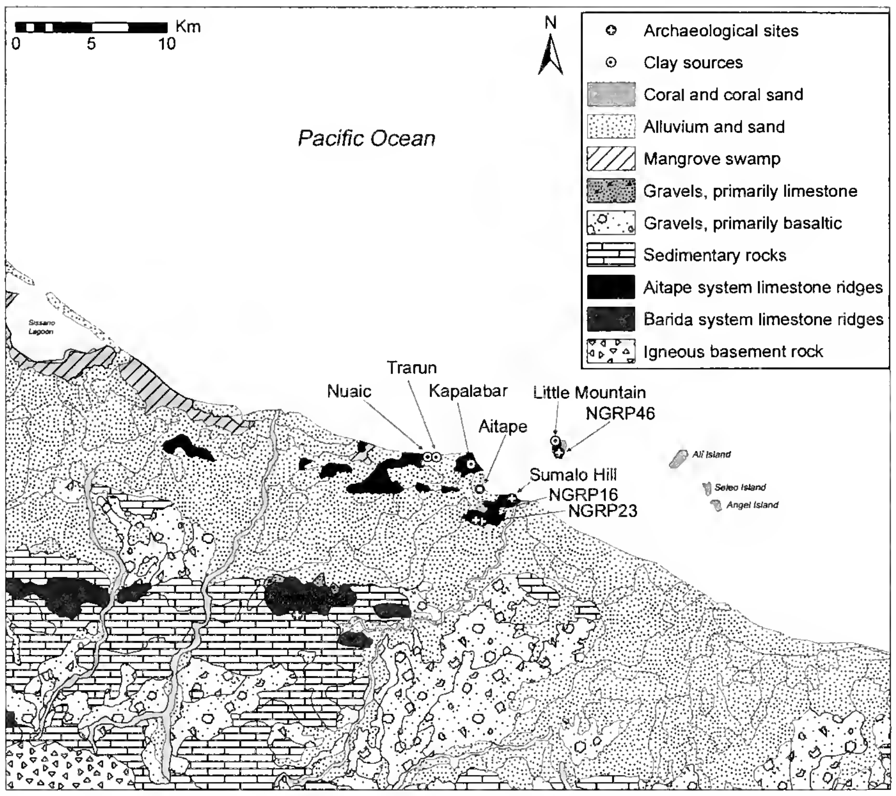

FIG. 13.12. Geology of the foothills and floodplains in the Aitape area, with archaeological sites and ethnographically documented clay sources indicated.

from comparison with raw material samples, and from the almost exclusive inclusion of ceramics from Serra and Leitre, that the Serra Hills reference group represents a chemical signature associated with production in the area between Serra and Leitre.

On the basis of membership probabilities, two of the clays collected from Tumleo Island potters, TM165CL and TM167CL, can be associated with the Aitape-Barida 1 reference group. These are, respectively, the *paic nuwaic* ("black clay") samples taken from the mainland near St. Mary's (TM165CL) and from the "Little Mountain" source on Tumleo (TM167CL). TM165CL differs somewhat from the Little Mountain clay chemically, however, in being enriched in a series of transition and poor metals, and having a lower Sr concentration. In contrast, the *paic rai* ("red clay") sample, TM166CL, though described by May and Tuckson (1982, p. 310) as the primary ingredient in modern Tumleo Island pastes, has a negligible membership probability in any of the ceramic reference groups, primarily because it is far more calcareous than the analyzed ceramics. The experimental mixture of three mainland clays, TM456, also does not exceed 1% probability of membership in any of the chemical groups, suggesting that the recipe utilized to produce this briquette does not accurately match that used by modern or prehistoric Aitape area potters.

However, differing mixtures of the measured clays, all weathered from limestone ridges of the Aitape land system, could potentially account for the chemical variation of the different Aitape-Barida reference group ceramics. While the Aitape-Barida 1 ceramic group is chemically consistent with production from relatively pure *paic nuwaic* type clay, in Figure 13.10, it is evident that the elevated metal concentrations present in the Aitape-Barida 2 reference group ceramics relative to Aitape-Barida 1 pottery are also present in some of the mainland clays utilized by modern Tumleo potters. This suggests that Aitape-Barida 2 ceramics may represent a variant paste recipe produced using clays of the Aitape-Barida system limestone ridges.

The two modern Tumleo pots analyzed, TM0013 and TM002, are approximately intermediate chemically between the Aitape-Barida 1 and Aitape-Barida 3 reference groups, and, as seen in Figure 13.9, it is evident that a mixture of the Little Mountain clay with some of the mainland clays would produce a chemical signature consistent with the modern Tumleo pottery. In particular, use of *paic rai*/red clay as a principal ingredient, as observed by May and Tuckson (1982), could explain both the lower Sr and the higher Ca concentrations found in the modern Tumleo pottery when compared to the prehistoric Tumleo pottery. Both of these modern pots have high probabilities of projecting into the Aitape-Barida 3 reference group (Appendix 13.3), though each also has a low probability of belonging to either the Aitape-Barida 1 or the Aitape-Barida 2 reference group. This finding strongly suggests that the chemical signature associated with the Aitape-Barida 3 reference group is the result of production from a recipe similar to that employed by modern Tumleo potters using raw materials associated with the Aitape and Barida land system limestone ridges.

While the general chemical characteristics of the Aitape-Barida 1–3 chemical reference groups strongly suggests that they were produced in the Aitape region of the coast using variant paste recipes, it is difficult to suggest a more geographically specific provenience interpretation for these three chemical groups. Outcrops of Aitape system limestones are distributed in a series of east–west-running ridges, the first of which runs just north of Wom/Aiser, while a second line of limestone ridges outcrop as hills closer to the coast, including around the modern town of Aitape (Fig. 13.12). The Little Mountain outcrop on Tumleo is an extension of this second line of ridges that has not been attached to the coast by progradation. While no clay samples from Barida system limestone ridges were available for analysis, these ridges are also associated with the Bliri volcanic Miocene/Pliocene deposits (Haantjens, 1972), and as such there is no reason to suspect that clays obtained there should chemically differ from those obtained from outcrops nearer to the coast or on Tumleo Island. In other words, if pottery were produced at Wom in the past, and potters selected local clays for producing their ceramics, the pottery they produced would not necessarily be chemically distinct from pots produced on Tumleo Island or the adjacent mainland near modern-day Aitape.

The criterion of relative abundance (Rice, 1987, p. 177)—the expectation that chemical paste types will be most abundant at the source of manufacture—would suggest that Aitape-Barida 3 reference group ceramics, almost all of which come from contexts in the immediate area around the town of Aitape, may have been produced in the vicinity of Mount Mario during the period in which Sumalo Ware was popular. As most Sumalo Ware excavated from NGRP 46 on Tumleo belongs to the Aitape-Barida 2 reference group, it is likely that Sumalo Ware was produced both on the mainland and on Tumleo Island.

It is also somewhat troubling that excavated material from NGRP 46, which belongs almost exclusively to the Aitape-Barida 2 reference group, should differ from material surface collected at the Nyapin graveyard locality, assigned mostly to the Aitape-Barida 1 reference group, as these are in reality different parts of the same site area. The difference is clearly not chronological, as Wain and Aiser ceramic material from NGRP 46 falls into the Aitape-Barida 2 reference group, and surface-collected Wain and Aiser material from Nyapin graveyard projects into Aitape-Barida 1. It is possible that this difference could be the result of postburial alteration, although it is unclear why material that had been buried for centuries and then excavated during grave digging, presumably since World War II, should more closely resemble raw clay samples than material that had remained in the ground until excavated archaeologically in 1996. Furthermore, the difference in relative concentrations of Si and Al between these two chemical reference groups is difficult to account for in this way, but similar differences in chemistry exist between the clays collected by Tumleo potters on the mainland and at the Little Mountain source.

The chemical differences between Aitape-Barida 1 and 2 sherds might plausibly result from the use of two or more clay sources that represent differential samples of the overall chemical variability present in the Aitape-Barida system limestone. For the moment, it is unclear whether the division of Aiser and Wain pottery into two distinct chemical groups implies the existence of multiple production centers for Aiser and Wain pottery or the presence of more than one tradition of paste preparation at Nyapin graveyard/NGRP 46. However, the three Aitape-Barida chemical reference groups do represent a robust chemical signature for ceramic production in the Aitape area spanning the past 2,000 years that can be distinguished from ceramics produced farther west in the Serra Hills.

Ramu Ceramics—Seven of eight sherds analyzed from Ramu cluster together chemically, although many of them overlap statistically with some of the western Sepik reference groups (Appendix 13.3), particularly the Serra Hills reference group, and, to a lesser degree, the Aitape-Barida 1 reference group as well. However, as is evident in the principal components plot (Fig. 13.8), these seven Ramu sherds have far lower Sr and Ca concentrations than sherds included in the Aitape-Barida 1 and 2 groups. Figure 13.13, a bivariate K-Nb plot, shows that these seven Ramu sherds are also chemically distinct from the Serra Hills and Aitape-Barida 3 reference groups as well as from all measured clay samples.

Sherd RM1561A, from Ramu, is distinct from the other seven Ramu sherds chemically, and has a high probability of

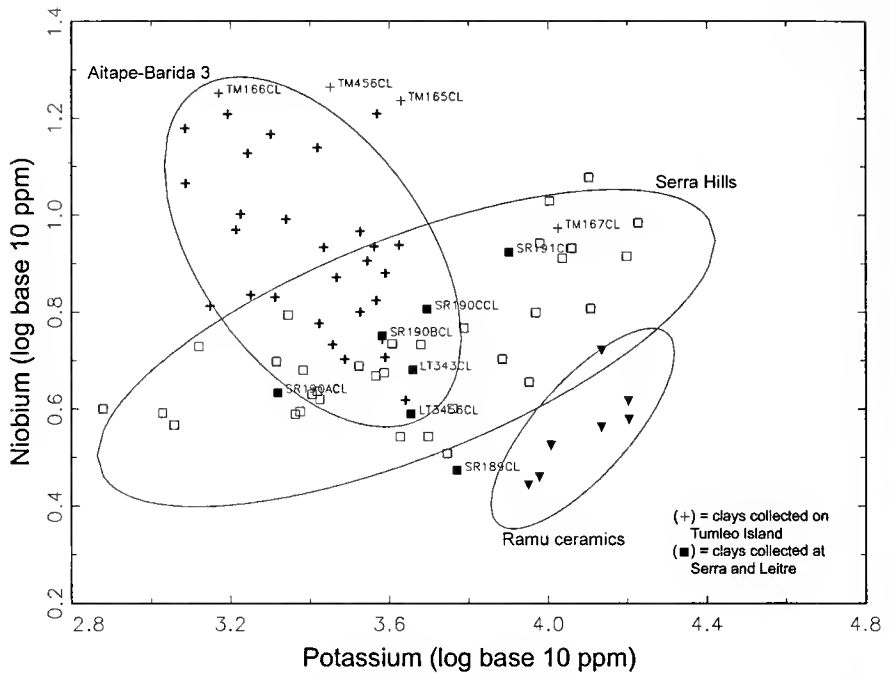

Fig. 13.13. Bivariate plot of logged potassium and niobium concentrations showing distinction between Ramu ceramics and Aitape-Barida 3 and Serra Hills reference group ceramics. Serra Hills and Tumleo Island clays are also displayed. Ellipses represent 90% confidence limits for group membership.

membership (Appendix 13.3) and chemical signature (Fig. 13.8) consistent with inclusion in the Aitape-Barida 1 reference group. This finding suggests that this sherd either was not produced at Ramu or was produced there using clays weathered from Aitape-Barida system limestone. Such outcrops are present some 8 km east of Ramu.

Eastern Sepik Ceramics

The principal components biplot indicates that the ceramics recovered from sites at the eastern end of the study area (Walis Island, Tarawai Island, and Kaiep) are generally depleted in trace element concentrations relative to those from the western end of the Sepik coast. A very high percentage (42 of 66 sherds, or ~64%) of sherds from eastern sites could not be assigned to one of the defined chemical reference groups—at present, the chemical data allow the assignment of a production provenience for only a handful of sherds of Aiser and Wain pottery recovered on Tarawai that can be assigned to the Aitape-Barida chemical reference. The remainder of the Tarawai and Walis sherds cannot be linked to production in either the Serra Hills or the Aitape region, and were presumably either locally produced or else acquired from other production centers. The ceramics from Tarawai are particularly variable chemically, suggesting that ceramics acquired from a number of producers were collected from archaeological sites there.

Buamunding Reference Group Ceramics—The Walis Island ceramics scoring low on PC1 in Figure 13.8 are all decorated sherds recovered at Walis Buamunding, and are consequently referred to as "Buamunding reference group" ceramics. The remaining sherds recovered on Walis Island do not group with these, and on the principal components plot, many overlap with ceramics from sites at the western end of the Sepik coast. A bivariate plot of logged Pb and Ba concentrations (Fig. 13.14) shows separation between Buamunding decorated sherds, the seven samples from Kaiep, and a combined "Western Sepik" chemical group comprising Serra Hills and Aitape-Barida reference group ceramics as well as those from Ramu. The small number of sherds in the

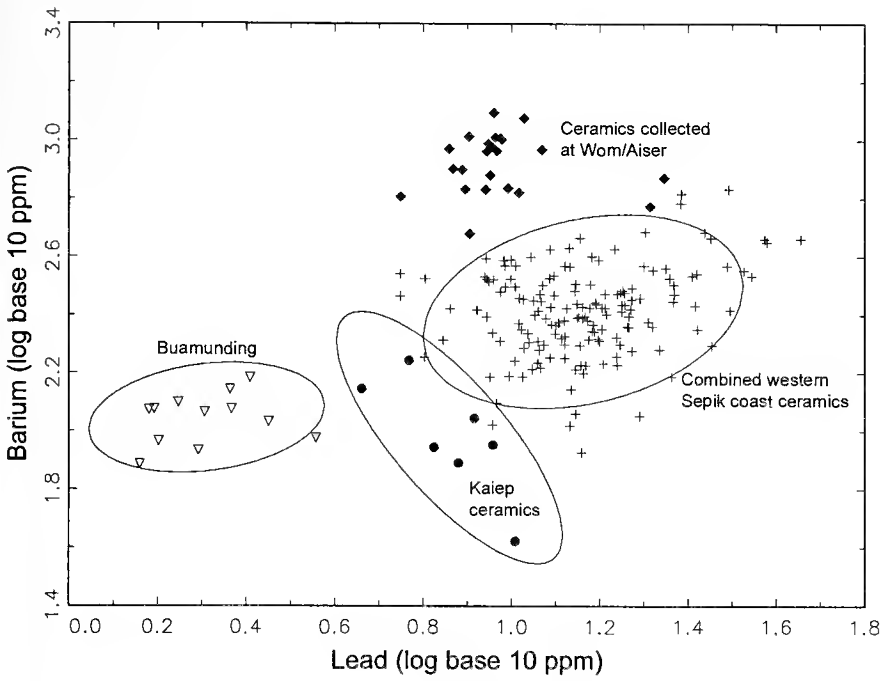

FIG. 13.14. Bivariate plot of logged lead and barium concentrations showing distinction between western Sepik sites (Aitape, Tumleo, Ramu, Serra, and Leitre), Kaiep, and samples included in the Buamunding reference group. Wom/Aiser samples are plotted but were not used in the calculation of confidence ellipses because of concerns of postdepositional addition of barium. Ellipses represent 90% confidence limits for group membership.

Buamunding reference group precludes a full statistical comparison with the remaining chemical reference groups. However, even using only 10 principal components accounting for 87.3% of the total variance in the data, Buamunding reference group sherds are clearly distinct from all western Sepik reference groups (Appendix 13.3).

As no clays from Walis or pots known to have been produced there were available for comparison, it is difficult to know whether the pottery found at Buamunding represents local production on Walis Island in the past or importation of ceramics from somewhere else. If pottery was produced on Walis, clays must have been obtained elsewhere. Dickinson's petrographic analysis of sherd WL1611A (Chapter 12), included in the Buamunding reference group, indicates that its mineralogy is consistent with production on the New Guinea mainland. The Buamunding reference group sherds are clearly distinct from both the western Sepik chemical groups and the sherds analyzed from Kaiep as well as those collected on New Britain that were probably made on the Huon peninsula. These areas can be ruled out as the source of Buamunding decorated pottery, the origins of which remain uncertain.

KAIEP CERAMICS—Similar to the Buamunding reference group ceramics, Kaiep ceramics are depleted in a host of trace elements relative to the western Sepik reference group ceramics, though to a lesser degree (Fig. 13.14). May and Tuckson (1982, p. 304) describe the clay used by Kaiep potters as a yellowish brown fine-grained clay containing gravel and fine quartz, obtained from a steep hill immediately behind the village. These clays may weather from exposed igneous basement rock, which could explain the chemical differences between Kaiep sherds and those analyzed from farther western localities. Calculation of membership probabilities in the four defined reference groups indicates that there is statistical overlap between some Kaiep ceramics and ceramics included in the Serra Hills reference group. However, five of the seven sherds analyzed from Kaiep have negligible probabilities of inclusion (Appendix 13.3), suggesting that if more samples were run, a compositionally distinct Kaiep chemical group could be defined.

TARAWAI CERAMICS—In contrast to the nearby island of Walis, where some of the analyzed sherds form a distinct, coherent chemical group, those analyzed from Tarawai Island are chemically very heterogeneous, and none form a coherent chemical group. The fact that none of the Tarawai sherds cluster together strongly suggests that Tarawai Islanders have over time received pottery from a number of different production locations. A handful of ceramics, principally of either Aiser Ware or Wain Ware (Wain sherds TW1521 and TW1538 and Aiser sherd TW16918), project into either the Aitape-Barida 1 or 2 reference groups. Several other Tarawai sherds, as well as a few from Walis Island, have low probabilities of membership in the Serra Hills reference group, but few of these probabilities exceed ~5%, and given the known statistical overlap between Kaiep and Serra Hills ceramics, it seems more probable that most of this pottery was produced on the eastern end of the coastal Sepik mainland. Analysis of a larger number of sherds from Kaiep will be needed to test this likelihood—initial inspection of bivariate plots shows that a number of unassigned Walis and Tarawai sherds consistently fall within the 90% confidence ellipse for Kaiep ceramics.

The small number of sherds from New Garden Area A identified as potential "Type X" style sherds, TW1691–1692, TW1695, and TW16910, also do not project into the defined reference groups, though one, TW1695, has a low probability of membership in the Serra Hills reference group. These sherds may have been imported to Tarawai as well, though from where is uncertain. None of the Tarawai sherds is similar to the Huon peninsula sherds chemically. Although the Huon peninsula has been suggested as the probable production location for Type X pottery (Specht et al., 2006, p. 40), the sherds from Tarawai do not appear to have been produced there, suggesting perhaps that Type X may have been a more widely distributed style than hitherto suspected.

Comparison of Chemical and Petrographic Results

The chemical results presented here in many ways confirm the conclusions drawn by Dickinson (Chapter 12) concerning the association between temper types and production location (Table 13.8). Temper sands of the types represented by temper groups A–D and G, although associated principally with the Serra Hills and Aitape-Barida 3 reference groups, also occur at Ramu (group D), at Kaiep (group A), and among unassigned sherds from Tarawai and Walis Islands. Although temper group G is the only type that occurs in ceramics assigned to the Aitape-Barida 3 reference group, two sherds from contexts near Aitape assigned by Dickinson to temper group G can be assigned to the Serra Hills reference group, and none of the group G sherds recovered on Tarawai project into the western Sepik reference groups. These observations suggest that the temper sands found in group G sherds are widely available along the Sepik coast, and provide little provenience information.

In contrast, group E temper is exclusively associated with ceramics of the Aitape-Barida 1 reference group. Although two sherds (TMNG46B–C) from NGRP 46 on Tumleo Island with group E temper are unassigned, one sherd appears to be a statistical outlier of the Aitape-Barida 2 reference group, while the other has low probabilities of belonging to both the Aitape-Barida 1 and the Aitape-Barida 2 reference groups. Dickinson has described this temper as being naturally

TABLE 13.8. Comparison of temper group assignment and chemical reference group assignment.

Temper group	Chemical group							
	Serra Hills	Aitape-Barida 1	Aitape-Barida 2	Aitape-Barida 3	Buamunding	Ramu	Kaiep	Unassigned
A	3						1	
B	3							2
C	3							5
D	1					1		2
E		8						2
F								2
G	2			4				8
Outlier								1

occurring rather than manually added—as Aitape-Barida 1 sherds were chemically most similar to samples of *paic nuwaic* clay, it seems likely that temper group E is strongly associated with the Aitape-Barida 1 chemical group precisely because these ceramic pastes represent minimally altered clays weathered from the tuffaceous limestone of the Aitape area. In contrast, Dickinson interprets temper groups A–D and F–G as deliberately added sands, which may explain mismatches between these temper groups and the chemical groups defined in the present study. For instance, the two sherds belonging to temper group F, TM1772 and TW1762, could not be assigned to a chemical group but differ from Aitape-Barida 1 ceramics principally because of elevated calcium concentrations. Temper group F differs from group E only by the apparent manual addition of sand containing calcareous grains, suggesting that group F sherds may represent a variant recipe used by potters in the Aitape area.

The temper data do, however, lend an additional line of support to some of the chemical group assignments made in the present study. For instance, sherds from Walis and Tarawai Islands assigned by Dickinson to temper group E also have substantial probabilities of membership in the Aitape-Barida 1 reference group, suggesting that they were obtained from somewhere in the Aitape area. The only two Wom/Aiser sherds not assigned to the Aitape-Barida 1 reference group, WM6151A and WM6153A, also are the only two sherds from Wom/Aiser not assigned to temper group E—WM6151A contains type D temper, and WM6153A contains type C temper. Both sherds can be assigned to the Serra Hills chemical reference group, and may have been obtained by exchange with people living to the west of Wom.

Sherd LT6031A, which Dickinson identified as an outlier petrographically, does not group with any of the identified chemical reference groups. Relative to the Sepik coast ceramics, LT6031A exhibits particularly low rare earth concentrations as well as low Be, Cs, and Y concentrations. Dickinson describes it as derived from "naturally ashy soil rich in juvenile tephra" and suggests a possible origin in the Shouten Islands east of Wewak, where the nearest Quaternary volcanoes are located (Dickinson, 2001). The chemical data reinforce this interpretation—this sherd clearly is a long-distance import to Leitre.

Discussion

The methodological goals set out for this study generally were met successfully. The chemical analyses, perhaps unsurprisingly, linked all analyzed obsidian specimens to known flows in island Melanesia, and demonstrate the utility of a dual methodology employing p-XRF to rapidly and nondestructively characterize large numbers of specimens, and LA-ICP-MS as a minimally destructive alternative for very small flakes measurable only with reduced accuracy by p-XRF. Interpretation of the ceramic chemical results has proved more challenging but has been similarly successful in identifying sufficient patterned chemical variability among different ceramic assemblages to allow robust geographical interpretations as to where many of the analyzed sherds were produced. There are, of course, limits to the resolution that chemical analysis can provide. For instance, while pottery recovered near Leitre is in many cases visually distinct from that found at Serra, the parent geologies on which the two localities are located, and from which potters obtained their raw materials are similar enough to preclude a meaningful distinction between pottery from the two villages on the basis of chemistry alone.

What is possible is the assignment of sherds to particular sections of the coast based on their chemical profiles—the Serra Hills are chemically distinct from the Aitape region, and pottery from both areas can generally be distinguished chemically from pottery produced on the eastern end of the Sepik coast. Conversely, this means that ceramics that were produced at one place and transported to another can be recognized within the limits of geographical resolution imposed by the geochemical variability of the coastline.

Changing Patterns of Obsidian Procurement on the Sepik Coast

Our chemical analyses of obsidian (Table 13.9) broadly confirm trends noted by Terrell and Welsch (1997, p. 562) in their interpretation of the results obtained by relative density measurements. Assemblages that are believed to pre-date ~2,000 BP (i.e., Kobom and Ali Island) contain higher percentages of Talasea obsidian than assemblages believed to postdate 2,000 BP. The high frequency of Talasea obsidian is most pronounced on Ali Island—some 56% of the obsidian collected by Terrell and Welsch comes from there, while at Kobom and adjacent inland sites, some 17% of the collected obsidian originated at Talasea. In comparison, no other analyzed assemblage contains more than 10% obsidian from Talasea. Only a single piece of Talasea obsidian was identified in the Nyapin levels at NGRP 46, and no Talasea obsidian was identified from any of the Sumalo Ware–associated

TABLE 13.9. Percentage totals of obsidian from each source, grouped by site and chronological context. Values in bold represent totals for pooled contexts, while unbolded values are sublocales or units within each pooled value when present. Values in brackets are total number of specimens represented in each cell.

	Source			
Site/period	New Britain	Umrei	Wekwok	Pam Lin
Ali	**56% (15)**	**33% (9)**	**4% (1)**	**7% (2)**
Kobom	**17% (23)**	**58% (78)**	**16% (22)**	**9% (12)**
Aitape	**0%**	**83% (29)**	**3% (1)**	**14% (5)**
Sumalo	0%	88% (22)	4% (1)	8% (2)
Sumalo-Wain	0%	70% (7)	0%	90% (3)
Tarawai	**2% (4)**	**81% (131)**	**5% (8)**	**11% (18)**
Tumleo	**4% (3)**	**54% (43)**	**13% (10)**	**30% (24)**
Nyapin	4% (1)	65% (15)	0%	30% (7)
Sumalo	0%	30% (3)	20% (2)	50% (5)
Aiser	4% (1)	56% (14)	16% (4)	24% (6)
Wain	10% (1)	70% (7)	10% (1)	10% (1)
Surface	0%	33% (4)	25% (3)	42% (5)

assemblages at NGRP 46 or on the adjacent mainland around Aitape. In later assemblages from the Aitape area associated with Aiser and then Wain pottery, Talasea obsidian remained relatively infrequent—single flakes were identified in the Aiser and Wain levels at NGRP 46, but no Talasea obsidian was identified from mainland sites. A chi-square test indicates that the difference in frequency of Admiralty versus Talasea obsidian between "early" and "late" assemblages is highly significant ($\chi^2 = 46.75$, df = 4, $p < 0.001$, $n = 425$), with suspected early contexts containing significantly more Talasea obsidian than assemblages after ~2,000 BP.

The disappearance of Talasea obsidian from assemblages around 2,000 BP was a coastwide phenomenon. While 43% of the obsidian specimens from Simindibubu and Sareta on Tarawai (suspected to be contemporaneous with Nyapin Ware on Tumleo) as measured by relative density were assigned to the Talasea source (Terrell & Welsch, 1997, p. 562), only 2% of the 161 flakes from there analyzed by chemical means were assigned to Talasea. This discrepancy in results between the two methods can probably be explained by the presence of 11% Pam Lin obsidian at Simindibubu and Sareta, which was probably misidentified as Talasea obsidian in the relative density study. This also casts doubt on the relative density results for more recent Tarawai assemblages, from which 29% of the specimens analyzed were assigned to the Talasea source (Terrell & Welsch, 1997, p. 562)—it will be necessary to chemically analyze these later assemblages in the future.

All assemblages other than those collected on Ali Island are dominated by the more proximal Admiralty sources—between 70% and 100% of all obsidian reaching the Sepik coast originated at either the Lou Island Umrei, the Lou Island Wekwok, or the Pam Lin flow. Of these, Umrei obsidian was the predominant variety imported to the Sepik coast, followed by Pam Lin and Wekwok obsidian. Arrayed chronologically, there are apparent differences in the relative frequencies of the three Admiralty types—for instance, Pam Lin and Wekwok obsidians are somewhat more frequent in the Sumalo and Aiser levels at NGRP 46 than in the earlier Nyapin or later Wain levels (Table 13.9), with Umrei correspondingly less common. However, this difference in frequencies of the different Admiralty subsources over time is not statistically significant ($\chi^2 = 4.15$, df = 6, $p > 0.60$, $n = 241$). Pooling the Lou Island subsources marginally increases the significance of the observed differences ($\chi^2 = 2.31$, df = 3, $p > 0.50$, $n = 241$) but again falls well short of statistical significance. Similarly, including only the Lou Island subsources in the analysis produces an insignificant test of difference ($\chi^2 = 4.211$, df = 3, $p > 0.20$, $n = 202$) though more highly significant than changes in Pam Lin obsidian frequency.

There are, however, interesting differences between some of the obsidian assemblages postdating ~2,000 BP included in the study. Although both the Nyapin levels at NGRP 46 (4%) and the Tarawai Island assemblages (2%) contain low proportions of New Britain obsidian, there is an apparent difference in the relative frequencies of the Admiralty subsources. The Simindibubu and Sareta assemblages contain 81% Umrei obsidian, while the Nyapin levels at NGRP 46 contain only 61%, with the difference made up primarily by Pam Lin obsidian (11% vs. 30%). The two assemblages are significantly different at the 0.05 level ($\chi^2 = 8.20$, df = 3, $0.04 < p < 0.05$, $n = 183$). The relatively high frequency of Pam Lin obsidian present on Tumleo in the Nyapin levels continues into the succeeding Sumalo levels—50% of the analyzed material in the Sumalo levels derives from Pam Lin. On the adjacent mainland near Aitape, assemblages associated with Sumalo Ware contain only 8% Pam Lin obsidian. This difference is not statistically significant ($\chi^2 = 6.39$, df = 3, $0.09 < p < 0.10$, $n = 47$), but the small number of Sumalo specimens analyzed from NGRP 46 (10) and the presence of zero values in some cells of the chi-square contingency table in this case suggest that analysis of more material might validate the difference between the two assemblages.

Ceramic Production and Transport

Evidence for the transport of pottery is provided by sherds that project into a chemical reference group not associated with production at the locale where the sherd was recovered (Table 13.10). As the majority of the analyzed pottery sherds were not systematically or randomly sampled, the data reported here do not allow for a robust assessment of the volume of ceramic transport but do give some indication as to the directionality of social and economic connections over time along the coast.

In addition to the single Lapita sherd from Ali, which may have originated elsewhere, there is some evidence for ceramic transport as far back as Nyapin times. Although current information is not sufficient to enable us to suggest a definitive point of origin, one sherd, TMNG4603, recovered from the Nyapin levels at NGRP 46 is chemically nonlocal to the Aitape area, having particularly low V, and high Ca and Sr concentrations. This interpretation of this sherd is strengthened by its stylistic characteristics, including a pronounced shoulder, that are unlike other Nyapin ceramics recovered on Tumleo. Another sherd from the Nyapin levels at NGRP 46, TMNG46D, projects into the Aitape-Barida 3 reference group, but this need not imply a mainland origin given the availability of similar raw materials on Tumleo itself. Alternatively, this could be an early indication of Tumleo potters utilizing mainland materials.

If the pottery from Sareta and Simindibubu on Tarawai Island is indeed as old as Nyapin ceramics on Tumleo, then Tarawai Islanders must also have been actively engaging in ceramic exchange during the first half of the first millennium

TABLE 13.10. Assignment of ceramics to chemical reference groups by original find spot.

Locale/sublocale	Serra Hills reference	Aitape-Barida 1 reference	Aitape-Barida 2 reference	Aitape-Barida 3 reference	Buamunding reference	Ramu	Kaiep	Wanigela	New Britain	Manus	Unassigned
	Chemical group assignment										
Leitre	**10**										**2**
Isi	6										1
Nowage Village	4										1
Serra	**23**	**1**									1
Rainuk 606	9	1									
Rainuk 608	1										**1**
Rainuk 609	11										
Serai	1										
Ramu Village		**1**				**7**					
Aitape	**4**	**5**		**29**							**5**
Sumalo Hill	4			8							3
NGRP 16		2		13							1
NGRP 23		3		8							1
Tumleo Island		**23**	**71**	**3**							**13**
Ethnographic collection				2							
Ainamul Hamlet		1									1
Wain Locality		7									
Nyapin		14									6
NGRP 46		1	71	1							6
Ali Island	**1**										**1**
La'ai	1										
Tubungbale Area A											1
Wom/Aiser	**2**	**24**									**1**
	2	24									1
Walis Island		**1**			**12**						**9**
Lakeba											5
Buamunding		1			12						2
Kambilal Hamlet											2
Tarawai Island		**3**	**1**								**33**
Munchika School Area 2		2									13
Munchika New Garden Area A			1								6
Munchika New Garden Area B											2
Simindibubu											6
Tawatohui		1									1
Sareta											3
Tarawai Village											2
Kaiep							**7**				
Wanigela								**9**			
Manus Island										1	
New Britain									**4**		
Solong									2		
Cape Merkus									2		
Total	**40**	**58**	**72**	**32**	**12**	**7**	**7**	**9**	**4**	**1**	**65**

AD. None of these early sherds can be linked to any of the defined chemical reference groups, suggesting exchange with areas outside of those included in the present study. Although some of the Sareta and Simindibubu sherds are chemically similar to one another, on the whole, the two assemblages exhibit a high degree of chemical variability, indicating that the Sareta and Simindibubu sherds probably were acquired from several sources. One of the sherds analyzed from Simindibubu, TW1712B, comes from a shouldered vessel similar to sherd TMNG4603, and the two were initially suspected to have been produced at the same place. However, the two do not appear to be chemically similar to each other.

Sumalo Ware potsherds available for study are only from the immediate area around Aitape and from NGRP 46 on Tumleo. Several Sumalo Ware pots from NGRP 46 are unassigned but appear to be either statistical outliers of Aitape-area production or else have overlapping probabilities of membership in one of the three Aitape-Barida reference groups. There is nothing to suggest that any of these unassigned sherds were produced outside the Aitape area, however. Four Sumalo Ware sherds from Sumalo Hill itself do project into the Serra Hills reference group and were therefore likely produced somewhere between modern-day Serra and Leitre in the past, suggesting that production of this ware extended beyond the immediate Aitape area.

Evidence for ceramic transport is better attested during the second millennium AD, reflecting the larger sample size relating to the Aiser, Wain, and other ceramic wares. Two Wom/Aiser sherds were sourced to the Serra Hills, while an Aiser sherd, TW16918, recovered at New Garden Area A on Tarawai is assignable to the Aitape-Barida 1 reference group, suggesting that east–west connections along the coast had been established by then. A Wain sherd produced in the Aitape area recovered at Serra Rainuk 606 (SR6069), and two Wain sherds recovered at Tarawai Munchika School Area 2 (sherds TW1521 and TW1538) together may be taken to infer that connections existed from one end of the study area to the other after ~AD 1500. Undated surface finds additionally connect Ali Island to Serra (sherd ALI638), Ramu to the Aitape area (sherd RM1561A), and Walis Buamunding to the Aitape area (sherd WL1612A). A sherd from Tarawai Tawatohui, TW1541, projects into the Aitape-Barida 1 reference group and demonstrates the continuance into recent times of networks of ceramic transport that connected Tarawai Islanders and people living in the Aitape area.

Patterns of Interaction on the Sepik Coast over Time

While representing only a fraction of the total amount of goods that moved along the Sepik coast in prehistory, the present data reveal a number of emerging general trends regarding the ways in which people on this coast and nearby offshore islands interacted over time with one another and with people living in the wider Melanesian world. Sepik coast peoples were evidently tied into Melanesian exchange networks directly enough for changes in obsidian procurement evident in the Bismarck Archipelago to also have been felt in the Aitape area, hundreds of kilometers distant. Although obsidian from seemingly pre-Nyapin times is currently available from only a handful of localities along the coast, these assemblages contain significantly higher frequencies of obsidian from Talasea on New Britain than assemblages after ~2,000 BP. If sites in the vicinity of Kobom are indeed as early as suspected, the present data extend the known distribution of obsidian during the mid-Holocene westward from the Sepik-Ramu delta (Torrence & Swadling, 2008, pp. 612–613), although it is worth noting that stemmed tools of the type found elsewhere in Melanesia during the mid-Holocene have, to date, not been found on the Sepik coast, perhaps indicating that sites in the Kobom area pre-date or postdate the popularity of stemmed tools in the Bismarcks.

The highest frequencies of Talasea obsidian are found in assemblages on Ali Island, and—if these assemblages are contemporaneous with the Lapita-style sherd recovered at Tubungbale—are consistent with the extensive distribution of Talasea obsidian during Lapita times, particularly during the early and late Lapita phases in the Bismarcks. Talasea obsidian is present at only low frequencies in assemblages believed to postdate ~2,000 BP, consistent with the reduced frequency of Talasea obsidian off New Britain in post-Lapita times elsewhere in Melanesia (Summerhayes, 2004, p. 151). Even so, Talasea obsidian continued to reach this part of New Guinea in small quantities during the last two millennia. Contact with the nearer Admiralty group surely pre-dated the last two millennia, and continued uninterrupted until historic times, with only minor fluctuations in the relative representation of the different Admiralty sources.

However, obsidian from the different Admiralty sources is not homogeneously distributed across the Sepik coast. Contact between people on the coast appears to have occurred through varying networks, resulting in different procurement patterns, even at very proximal places. If the assemblages associated with Nyapin ceramics on Tumleo Island are indeed roughly contemporary with those surface collected at Sareta and Simindibubu on Tarawai, then interactions on the Sepik coast must already have been characterized by differential participation in social networks as early as ~2,000 BP. Tumleo Islanders more frequently acquired obsidian from the Pam Lin source than did Tarawai Islanders—this cannot be accounted for by a model of "down-the-line" exchange, as such a model would require that Tumleo Islanders received their obsidian from places farther to the east, possibly including Tarawai, in which case frequencies of Pam Lin and Lou Island obsidian should be nearly identical on the two islands.

While Tumleo and Tarawai are separated by nearly 100 km, differences in procurement patterns are present on a much smaller geographical scale as well. Obsidian assemblages associated with Sumalo Ware pottery on Tumleo and the adjacent mainland near Aitape also differ in their relative representation of Lou Island and Pam Lin obsidian. The total absence of obsidian at collection locations in the Serra Hills is also noteworthy. This is particularly so at Rainuk Airfield, where Wain sherds produced in the Aitape area were found. While obsidian is found in contemporary assemblages farther east at NGRP 46 on Tumleo and Munchika School Area 2 on Tarawai, it is conspicuously absent in surface collections at Rainuk, and possibly indicates that obsidian did not move through the same social channels as pottery, which clearly did make its way from the Aitape area to Rainuk during this time.

The ceramic data similarly indicate that people living in nearby places have in the past engaged in quite different patterns of procurement. Although Walis and Tarawai islands are separated by a water gap of only 500 m, not a single analyzed sherd recovered on Tarawai could be linked to the Buamunding chemical reference group, and even the unassigned sherds from the two islands appear to be largely differentiable on bivariate chemical plots. The uncertainty regarding the age of the ceramics recovered on Walis makes it impossible to directly compare the data from there to particular contexts on Tarawai, but the current evidence strongly suggests that the social networks in which people living on Walis and Tarawai have engaged over time have been basically different—this despite both islands currently being occupied by speakers of the Ndu language and the close linkage between the two in terms of material cultural assemblages during the 20th century (Chapter 2). This in turn suggests that social networks in the past along the coast may have been as complexly patterned as today, and that individuals living next door to one another, and possibly even speaking the same language, may have engaged in visits and transactions with entirely different groups of people. In part, this may have been the outcome of entrenched cultural beliefs—for instance, one could draw a parallel with the ethnographically recorded social discontinuity between Serra and Leitre, where different kinds of goods were valued, and where exchange took place in very different social contexts—people at Leitre and farther west exchanged glass beads in the context of bride-price payments, while those at Serra did not (Welsch & Terrell, 1998, p. 71).

How, then, might past interaction patterns on the Sepik coast relate to modern cultural patterning? The present data suggest that the geographical divide into "neighborhoods" by third-order proximal point mapping presented by Terrell in Chapter 2 may have more ancient roots, specifically in regard to the "western" (representing primarily the Aitape area sites in the present sample) and the "central" (Tarawai and Walis) neighborhoods. Although some of the Wain and Aiser sherds found on Tarawai can be chemically linked to production in the Aitape area, these form only a small fraction of the total sherds analyzed from there. The majority of Tarawai and Walis sherds cannot be linked to the western Sepik chemical reference groups, do not form coherent chemical clusters, and appear to have been acquired from a variety of places.

In contrast, the majority of the ceramics from both the Serra Hills and the Aitape area sites form well-defined chemical reference groups with few unassignable sherds, indicating that almost all the analyzed pottery from the western end of the coast was produced in either the Serra Hills or the Aitape area. The overall impression is of more wide-ranging exchange networks on the eastern coast than the western coast in prehistory, consistent with Terrell's observation that the "western" neighborhood sites appear to interact more intensively with each other, while the "central" and "eastern" neighborhoods appear to engage in more outwardly focused social and economic networks. However, without a firmer grasp of exactly where most of the pottery recovered on Tarawai and Walis was made, the full extent to which people living on Tarawai and Walis interacted with people living farther to the east remains a subject awaiting further investigation.

Conclusions and Future Directions

People living along the northern coastline of New Guinea were engaged in the changing networks of exchange and interaction that characterized broader Melanesia, possibly as far back as the mid-Holocene. The present study indicates that changes in the scope and nature of these networks originating at obsidian sources in the Bismarck and Admiralty groups, within the distribution of the Lapita pottery complex, were also felt by the people of the Sepik coast. At the same time, the local networks through which these people interacted with one another appear comparable to the modern ethnographic record of social life on the coast. While it is probably beyond the resolution of the archaeological record to ever know whether trade "friendships" existed in the past as they do today (Welsch & Terrell, 1998, p. 54), whatever was going on for the last 2,000 years along the Sepik coast appears to have been structured by equally complex networks of exchange and interaction, with even very proximal places displaying very different material cultural assemblages, suggesting that the social relationships maintained by one village may have been quite different from those of their local neighbors. Identifying differential procurement patterns at proximal places may indeed be the key to mapping the overlapping boundaries of past social fields by identifying discontinuities in the distribution of particular material goods that represent points of less frequent interaction, visiting, and exchange.

While chemical characterization of archaeological materials has great promise as a means of delving into this past social world, there remain substantial gaps in our knowledge of Sepik coast prehistory that suggest avenues for further research. These include both the analysis of ceramics from other regions with which people on the Sepik coast may have been in contact and the collection of additional raw material samples that will help in further understanding the geographical resolution that chemical analysis of ceramic sherds can provide. The current results also provide strong justification for further excavations designed to recover both ceramics and obsidian from chronologically anchored contexts outside the immediate Aitape area—until such material is available, it will be difficult to address in more detail the directionality and intensity of social interaction over time.

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Appendix 13.1: Mean Concentration Values for the Four Identified Obsidian Sources.[a]

	Pam Lin				Umrei				Wekwok				Talasea			
	LA-ICP-MS (n = 26)		p-XRF (n = 47)		LA-ICP-MS (n = 32)		p-XRF (n = 264)		LA-ICP-MS (n = 12)		p-XRF (n = 41)		LA-ICP-MS (n = 24)		p-XRF (n = 22)	
Element	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Si	0.752	0.006			0.724	0.004			0.739	0.004			0.779	0.014		
Al	0.133	0.004			0.143	0.002			0.141	0.002			0.127	0.003		
Na	30,636	1,644			34,270	1,103			32,694	1,103			26,587	2,762		
K	35,562	3,175	33,907	3,733	32,294	1,693	30,969	2,215	31,747	1,693	30,801	2,016	26,671	5,043	26,858	818
Ca	8,242	3,149	4,570	1,086	13,971	3,490	8,789	3,229	12,544	3,490	6,856	1,255	12,048	3,588	7,200	2,993
Mg	653	104			1,440	254			1,342	254			1,068	97		
Fe	8,153	1,943	11,977	439	11,241	2,353	17,359	767	7,797	2,353	14,028	315	4,696	1,614	8,073	193
Ti	976	95	973	108	1,720	149	1,812	150	1,581	149	1,587	91	1,232	278	1,183	95
Be	2.9	3.8			2.2	0.3			2.5	0.3			0.6	0.2		
B	18.1	6.3			16.3	5.1			17.6	5.1			61.9	6.5		
Sc	3.3	0.4			4.4	0.3			4.1	0.3			3.3	0.5		
V	1.7	0.8			4.3	0.7			5.5	0.7			5.5	1.3		
Cr	1.4	3.3			1.1	0.7			1.5	0.7			1	2.8		
Mn	388	24	384	17	490	33	469	23	446	33	425	20	425	49	400	18
Co	0.89	0.38			2	0.3			1.6	0.3			0.8	0.4		
Ni	0.77	1.93			0.62	0.52			0.72	0.52			0.4	0.75		
Cu	6.65	11.35			6.4	2.8			7.4	2.8			5.6	11.2		
Zn	41.13	9.62	55	32	52.5	4.4	65	28	46.9	4.4	53	17	33	6.6	40	14
Rb	166.53	7.24	169	11	162.2	9.7	157	13	158.6	9.7	157	13	52.2	7.9	54	5
Sr	38	4.5	39	4	83.3	3.8	81	8	76.1	3.8	78	10	198.1	33.3	221	14
Y	39.9	3.4			43.9	3.6			39.6	3.6			20.7	2.7		
Zr	217.4	13.6	265	18	405.9	26.8	415	28	313.6	26.8	339	25	125.2	19.1	144	12
Nb	44.7	4.5	40	4	52.2	3.3	43	6	45.6	3.3	40	6	3	1.9	<LOD	<LOD
Sn	3.3	1.9			3.6	1.4			3	1.4			0.7	0.3		
Cs	2	0.1			2	0.2			2	0.2			1.5	0.3		
Ba	594	42	568	74	667	44	601	84	604	44	574	82	430	87	368	76
La	41.8	3.7			44.3	4.2			40.9	4.2			12.6	2.2		
Ce	84.7	4.5			88.7	5.5			81.6	5.5			26.3	4.3		
Pr	9.3	0.9			9.9	1			8.9	1			3.6	0.6		
Nd	31.4	3			33.9	3.5			30.9	3.5			14	2.1		
Sm	6.2	0.73			6.8	0.6			6	0.61			2.8	0.47		
Eu	0.87	0.11			1.18	0.1			1.01	0.1			0.65	0.09		
Gd	5.9	0.8			6.6	0.8			6	0.8			2.7	0.4		
Tb	1	0.11			1.1	0.1			0.99	0.1			0.49	0.06		
Dy	6.4	0.6			7.1	0.7			6.4	0.7			3.3	0.4		
Ho	1.41	0.17			1.55	0.18			1.43	0.18			0.74	0.09		
Er	3.9	0.3			4.4	0.4			4.1	0.4			2.1	0.3		
Tm	0.65	0.09			0.69	0.08			0.62	0.08			0.35	0.08		
Yb	4.6	0.4			5.1	0.4			4.7	0.4			2.5	0.3		
Lu	0.72	0.1			0.78	0.08			0.73	0.08			0.4	0.05		
Hf	8.2	0.6			12.2	1.1			10.3	1.1			4.3	0.7		
Pb	6.3	2			6.6	3.1			13	3.1			10.4	1.6		
Th	14.5	2.9			13.7	3.8			15.3	3.8			3.1	0.6		
U	3.7	0.6			3.5	0.9			3.8	0.9			1.9	0.3		

[a] SD = standard deviation; LOD = limit of detection.

Appendix 13.2: Mean Concentration Values for Ceramic Chemical Groups.[a]

Element	Serra Hills Mean	Serra Hills SD	Aitape-Barida 1 Mean	Aitape-Barida 1 SD	Aitape-Barida 2 Mean	Aitape-Barida 2 SD	Aitape-Barida 3 Mean	Aitape-Barida 3 SD	Buamunding Mean	Buamunding SD	Ramu Mean	Ramu SD	Kaiep Mean	Kaiep SD	Wanigela Mean	Wanigela SD	New Britain Mean	New Britain SD
Li	41	11	14	7	24	11	33	11	5	1	32	15	15	7	25	9	29	19
Be	1.6	0.5	1.6	0.5	1.9	0.7	1.9	0.7	0.4	0.1	1.2	0.6	1.2	0.4	2.6	0.8	1.2	0.7
B	27	16	20	8	43	38	22	12	9	3	30	22	26	9	31	19	231	190
Na	7,436	4,322	10,998	3,283	7,888	3,572	7,539	3,414	4,319	2,781	12,307	1,336	8,837	5,055	17,659	6,423	14,595	1,400
Mg	8,131	4,238	11,324	3,895	12,919	5,173	11,884	3,349	2,806	786	18,181	3,500	11,267	6,665	7,234	3,202	44,076	35,362
Al	128,475	13,169	135,071	16,514	162,921	21,215	145,088	18,815	107,550	17,583	102,585	13,655	113,633	15,218	141,386	13,303	67,515	24,554
Si	290,812	15,497	276,850	19,137	237,036	22,009	261,240	20,103	325,210	20,798	296,948	20,719	273,818	31,776	262,390	8,143	198,767	46,611
K	5,622	4,160	8,340	4,369	5,411	2,167	2,779	989	2,708	1,007	12,524	2,988	3,202	1,955	6,465	934	28,371	10,505
Ca	4,844	2,095	16,975	3,231	18,476	4,137	15,315	4,049	7,054	1,366	10,109	3,079	29,257	23,739	21,058	7,448	152,423	96,122
Sc	29.8	7.8	26.9	5.1	28.7	7.1	34.3	8.1	25.3	4.9	30.4	6.1	28.8	6.4	18.9	3.3	34.5	14.2
Ti	4,630	721	4,303	700	4,950	1,134	5,738	2,171	2,923	569	4,057	450	3,821	1,080	4,360	755	3,361	1,160
V	219	45	190	32	187	50	199	49	132	25	208	27	279	52	108	36	191	42
Cr	180	76	83	41	131	68	170	71	38	27	135	16	118	50	127	30	141	49
Mn	707	671	775	443	1,045	439	976	378	234	254	988	187	986	552	587	303	1,885	380
Fe	58,481	10,679	48,193	6,659	69,194	12,785	65,923	11,808	43,786	8,643	56,452	8,789	61,259	6,050	40,104	12,904	50,688	13,679
Co	34	19	29	14	30	11	38	20	6	4	32	20	21	14	14	11	29	6
Ni	125	68	57	35	108	58	187	99	14	4	79	15	58	40	54	19	58	21
Cu	67	28	137	49	204	78	120	46	54	16	78	31	73	30	54	21	176	102
Zn	116	38	91	31	200	101	148	84	95	51	142	40	79	10	255	137	401	260
Rb	39	23	35	15	41	17	15	10	31	13	51	17	12	7	49	8	55	32
Sr	112	51	536	176	645	200	150	85	98	28	176	33	261	160	865	330	1,164	591
Y	21	10	18	8	16	7	23	7	6	2	18	3	20	6	19	7	21	6
Zr	112	17	145	32	150	48	125	27	49	22	89	17	79	13	150	29	66	26
Nb	6	2	11	4	12	5	9	4	2	0.3	4	1	2	2	11	2	2	1
In	0.1	0.03	0.06	0.02	0.12	0.04	0.11	0.03	0.09	0.02	0.08	0.01	0.06	0.02	0.09	0.02	0.09	0.03
Sn	2.5	1.4	1.4	1.1	2.1	0.5	1.8	0.4	1.1	0.5	1.6	0.6	2.1	0.6	8.7	8	3	1.5
Cs	2.4	1.3	1	0.9	1.4	0.9	0.8	0.7	0.2	0.1	1.9	0.5	0.6	0.5	2.9	1.6	1.9	0.7
Ba[b]	202	66	293	58	287	112	294	87	113	22	301	64	103	44	2,386	1,200	217	85
La	12	6	22	10	14	7	21	8	3	2	10	2	11	3	26	6	10	3
Ce	34	15	51	19	30	12	38	12	8	4	27	5	22	6	50	14	18	6
Pr	3.9	1.8	5.8	2.7	4.7	2.2	6.9	3.2	1	0.6	3.1	0.4	2.8	0.6	7.3	2	2.7	0.8
Nd	16	7	23	10	19	8	30	13	4	2	14	2	15	4	30	9	13	4
Sm	4	2	5	2	5	2	6	2	1	0.5	4	1	4	1	6	2	4	1
Eu	1.4	0.7	1.6	0.6	1.8	0.6	2.3	0.6	0.3	0.2	1.3	0.3	1.1	0.5	1.8	0.3	1.1	0.3
Gd	5	4	4	2	9	4	7	3	1	0.4	4	2	4	1	6	2	3	1
Tb	0.7	0.4	0.6	0.3	0.8	0.4	0.8	0.2	0.1	0.1	0.6	0.1	0.5	0.1	0.7	0.2	0.6	0.3
Dy	4.2	2.1	3.4	1.5	3.2	1.3	4.8	1.2	0.9	0.3	3.7	0.7	3.5	0.9	3.8	1.3	3.5	1.1
Ho	0.9	0.4	0.7	0.3	0.7	0.3	0.9	0.3	0.2	0.1	0.8	0.1	0.7	0.1	0.8	0.2	0.8	0.2
Er	2.7	1.2	1.9	0.8	1.9	0.7	2.7	0.7	0.7	0.3	2.3	0.6	2.1	0.5	2.2	0.7	2.1	0.7
Tm	0.4	0.18	0.27	0.11	0.28	0.11	0.38	0.09	0.11	0.05	0.35	0.1	0.29	0.09	0.31	0.1	0.32	0.1
Yb	3.1	1.3	2	0.8	2.1	0.7	2.9	0.7	0.7	0.3	2.6	0.8	2.3	0.4	2.2	0.7	2.2	0.8
Lu	0.43	0.16	0.27	0.1	0.29	0.1	0.39	0.09	0.12	0.05	0.37	0.11	0.28	0.11	0.3	0.08	0.32	0.11
Pb	15	5	11	4	19	7	13	4	2	1	10	3	7	2	102	44	78	81
Bi	0.22	0.13	0.11	0.09	0.24	0.12	0.19	0.08	0.16	0.02	0.16	0.06	0.09	0.03	0.35	0.09	0.14	0.13
Th	5	2	3	1	3	1	3	1	1	0.2	3	1	2	1	9	2	1	1
U	2.3	1.3	1.2	0.8	1.6	0.7	1.2	0.7	0.4	0.2	1.1	0.2	0.6	0.3	2.2	0.6	1.4	0.9

[a] SD = standard deviation.
[b] Sherds from Wom/Aiser have been omitted for purposes of calculating barium concentrations.

Appendix 13.3: Group Membership Probabilities for All Analyzed Sherds Relative to the Five Defined Chemical Reference Groups

Sherd ID	Chemical group assignment	Reference group membership probability				
		Serra Hills	Aitape-Barida 1	Aitape-Barida 2	Aitape-Barida 3	Buamunding
LT6011A	Serra Hills	17.670	0.000	0.000	0.000	0.023
LT6011B	Serra Hills	12.033	0.018	0.000	0.005	0.018
LT6012A	Serra Hills	3.699	0.002	0.000	0.001	0.074
LT6012B	Serra Hills	36.772	0.000	0.001	0.011	0.024
LT6013	Serra Hills	27.205	0.378	0.010	0.088	0.025
LT6015	Serra Hills	55.427	1.509	0.399	0.073	0.032
LT6031B	Serra Hills	77.025	0.001	0.000	0.013	0.107
LT6032A	Serra Hills	20.287	0.000	0.000	0.001	0.060
LT6032B	Serra Hills	22.231	0.000	0.000	0.011	0.062
LT6033	Serra Hills	12.349	0.007	0.001	0.262	0.262
SR6061	Serra Hills	49.921	0.000	0.000	4.643	0.081
SR60610	Serra Hills	46.451	0.605	0.000	4.453	0.046
SR6062	Serra Hills	54.154	0.000	0.000	0.008	0.143
SR6063	Serra Hills	76.210	0.004	0.000	0.571	0.077
SR6064	Serra Hills	99.973	0.007	0.000	0.395	0.066
SR6065	Serra Hills	93.864	0.013	0.000	0.436	0.068
SR6066	Serra Hills	76.210	0.006	0.000	1.725	0.070
SR6067	Serra Hills	97.412	0.025	0.000	2.971	0.084
SR6068	Serra Hills	51.823	0.002	0.000	0.005	0.236
SR60812	Serra Hills	0.715	0.000	0.000	0.000	0.055
SR6091A	Serra Hills	54.776	0.000	0.000	0.019	0.319
SR6091B	Serra Hills	29.521	0.002	0.000	0.845	0.081
SR6092A	Serra Hills	34.003	0.000	0.000	0.894	0.503
SR6092B	Serra Hills	11.445	0.000	0.000	0.485	0.071
SR6093	Serra Hills	72.713	0.000	0.000	0.177	0.108
SR6094	Serra Hills	20.854	0.000	0.000	0.023	0.130
SR6095	Serra Hills	28.449	0.000	0.000	0.000	0.114
SR6096	Serra Hills	37.804	0.000	0.000	0.003	0.095
SR6097	Serra Hills	71.580	0.000	0.000	0.247	0.061
SR6098	Serra Hills	78.841	0.000	0.000	0.001	0.022
SR6099	Serra Hills	90.559	0.000	0.000	0.001	0.035
SR610	Serra Hills	98.301	0.002	0.000	0.005	0.043
ALI638	Serra Hills	72.678	0.000	0.000	0.000	0.016
AT649B12	Serra Hills	62.686	4.817	0.028	6.415	0.043
AT649B1A	Serra Hills	49.625	0.129	0.003	0.931	0.045
AT649B2A	Serra Hills	69.746	1.922	0.081	0.011	0.051
AT649B9	Serra Hills	83.753	4.159	0.048	0.048	0.042
WM6151A	Serra Hills	5.865	0.000	0.000	0.003	0.069
WM6153A	Serra Hills	41.007	0.007	0.046	0.184	0.049
TM1771	Aitape-Barida 1	0.000	1.842	0.227	0.243	0.017
TM1782	Aitape-Barida 1	0.006	85.646	0.047	0.032	0.018
TM1783	Aitape-Barida 1	0.000	15.156	0.000	0.001	0.009
TM1784	Aitape-Barida 1	0.000	15.156	0.000	0.000	0.019
TM1785	Aitape-Barida 1	0.000	44.230	0.003	0.000	0.018
TM17910	Aitape-Barida 1	0.000	94.210	0.002	0.235	0.018
TM17911	Aitape-Barida 1	0.000	3.438	0.000	0.000	0.077
TM17914	Aitape-Barida 1	0.053	75.088	0.615	15.161	0.023
TM17917	Aitape-Barida 1	0.026	56.103	0.002	8.339	0.031
TM17918	Aitape-Barida 1	0.000	31.224	0.050	0.054	0.020
TM17919	Aitape-Barida 1	0.000	27.120	0.019	0.049	0.022
TM17920	Aitape-Barida 1	8.360	94.565	0.051	39.697	0.030
TM1793	Aitape-Barida 1	0.001	76.605	0.521	0.004	0.031
TM1794	Aitape-Barida 1	19.318	64.421	0.833	19.147	0.031
TM1795	Aitape-Barida 1	3.928	86.496	0.000	18.518	0.034
TM1796	Aitape-Barida 1	0.563	18.496	0.000	0.003	0.018
TM1797	Aitape-Barida 1	0.000	75.760	0.205	0.015	0.029
TM1798	Aitape-Barida 1	0.000	32.680	0.002	0.199	0.013
TMNG46A	Aitape-Barida 1	0.000	2.937	0.000	0.180	0.024
WM61510	Aitape-Barida 1	0.091	54.097	0.099	16.953	0.017
WM61511	Aitape-Barida 1	0.000	95.423	0.000	0.001	0.021
WM61512	Aitape-Barida 1	0.000	26.200	0.000	0.005	0.036
WM61513	Aitape-Barida 1	0.000	12.278	0.005	0.019	0.031
WM61515	Aitape-Barida 1	0.000	85.464	0.000	0.019	0.021
WM61516	Aitape-Barida 1	0.000	46.039	0.000	0.057	0.026
WM61517	Aitape-Barida 1	0.000	0.519	0.000	0.000	0.043
WM61518	Aitape-Barida 1	0.000	32.727	0.001	0.026	0.024
WM61519	Aitape-Barida 1	0.000	99.863	0.352	2.040	0.023
WM6151B	Aitape-Barida 1	0.000	33.360	0.000	0.001	0.009
WM61520	Aitape-Barida 1	0.000	29.055	0.000	0.031	0.019

Appendix 13.3: *Continued.*

Sherd ID	Chemical group assignment	Reference group membership probability				
		Serra Hills	Aitape-Barida 1	Aitape-Barida 2	Aitape-Barida 3	Buamunding
WM61521	Aitape-Barida 1	0.000	89.557	0.007	0.005	0.024
WM61522	Aitape-Barida 1	0.000	98.316	0.233	0.170	0.027
WM61523	Aitape-Barida 1	0.000	98.648	0.000	0.115	0.018
WM6152B	Aitape-Barida 1	0.000	72.400	0.000	0.006	0.022
WM6153B	Aitape-Barida 1	0.467	21.092	0.044	6.233	0.026
WM6154	Aitape-Barida 1	0.000	65.000	0.015	0.006	0.024
WM6156	Aitape-Barida 1	10.389	34.857	0.206	2.044	0.079
WM6157	Aitape-Barida 1	1.528	9.207	0.000	0.395	0.117
WM6158	Aitape-Barida 1	1.932	5.469	0.181	3.048	0.041
WM6159	Aitape-Barida 1	0.000	86.549	0.023	0.952	0.034
WM616	Aitape-Barida 1	0.000	10.083	0.000	0.008	0.016
ATNG1606	Aitape-Barida 1	0.000	9.153	0.000	0.007	0.013
ATNG1607	Aitape-Barida 1	0.000	40.560	0.005	1.127	0.013
ATNG2301	Aitape-Barida 1	0.000	31.485	0.003	0.009	0.021
ATNG2308	Aitape-Barida 1	0.000	82.781	0.036	0.690	0.024
ATNG2309	Aitape-Barida 1	0.000	6.021	0.000	0.088	0.027
RM1561A	Aitape-Barida 1	0.000	9.766	0.000	0.001	0.011
SR6069	Aitape-Barida 1	0.000	32.316	0.000	0.009	0.015
TM178	Aitape-Barida 1	0.000	2.242	0.000	0.019	0.019
TM1781	Aitape-Barida 1	0.007	12.217	0.110	0.008	0.019
TM17915	Aitape-Barida 1	0.000	23.786	8.936	1.255	0.024
TW1521	Aitape-Barida 1	0.000	50.101	0.000	0.001	0.009
WM61514	Aitape-Barida 1	0.000	87.874	0.000	0.006	0.016
WM6152A	Aitape-Barida 1	0.000	8.788	0.000	0.166	0.033
TW1541	Aitape-Barida 1	0.000	6.340	0.002	1.927	0.021
WL1612A	Aitape-Barida 1	0.000	17.091	0.000	0.004	0.013
TMNG4601	Aitape-Barida 2	2.557	6.379	6.985	0.131	0.068
TMNG4602	Aitape-Barida 2	0.000	0.269	72.616	1.335	0.031
TMNG4604	Aitape-Barida 2	0.000	0.705	76.105	1.799	0.032
TMNG4605	Aitape-Barida 2	0.000	0.002	41.382	0.065	0.031
TMNG4606	Aitape-Barida 2	0.000	0.727	53.720	0.010	0.027
TMNG4607	Aitape-Barida 2	0.000	0.016	33.364	0.005	0.031
TMNG4608	Aitape-Barida 2	0.000	0.020	62.498	0.028	0.022
TMNG4609	Aitape-Barida 2	0.000	1.253	42.978	0.021	0.021
TMNG4610	Aitape-Barida 2	1.517	5.931	62.978	0.663	0.032
TMNG4611	Aitape-Barida 2	0.000	1.047	19.404	0.002	0.036
TMNG4612	Aitape-Barida 2	0.000	0.011	59.903	0.001	0.040
TMNG4613	Aitape-Barida 2	0.016	3.886	68.899	0.783	0.026
TMNG4614	Aitape-Barida 2	0.080	5.281	40.346	2.324	0.031
TMNG4615	Aitape-Barida 2	0.000	0.011	26.222	0.001	0.045
TMNG4616	Aitape-Barida 2	0.103	0.018	43.248	0.072	0.041
TMNG4617	Aitape-Barida 2	0.000	1.608	13.641	0.024	0.054
TMNG4618	Aitape-Barida 2	0.000	0.000	61.012	0.159	0.049
TMNG4619	Aitape-Barida 2	0.000	0.001	40.462	0.435	0.047
TMNG4620	Aitape-Barida 2	0.000	0.009	4.987	0.029	0.077
TMNG4621	Aitape-Barida 2	1.328	1.827	57.450	1.734	0.055
TMNG4622	Aitape-Barida 2	0.000	0.001	70.039	0.034	0.039
TMNG4623	Aitape-Barida 2	0.012	0.003	93.349	0.325	0.028
TMNG4624	Aitape-Barida 2	0.373	0.109	78.221	0.857	0.033
TMNG4625	Aitape-Barida 2	0.006	0.000	39.650	0.380	0.055
TMNG4626	Aitape-Barida 2	0.598	0.185	36.138	0.030	0.049
TMNG4627	Aitape-Barida 2	0.008	0.112	64.793	0.522	0.040
TMNG4628	Aitape-Barida 2	0.000	0.000	87.403	0.052	0.037
TMNG4629	Aitape-Barida 2	1.038	0.012	97.364	0.032	0.041
TMNG4630	Aitape-Barida 2	0.041	0.593	33.378	0.004	0.038
TMNG4631	Aitape-Barida 2	0.000	0.001	7.767	0.073	0.022
TMNG4632	Aitape-Barida 2	0.036	0.034	97.779	1.648	0.026
TMNG4633	Aitape-Barida 2	0.000	0.093	12.940	5.639	0.026
TMNG4634	Aitape-Barida 2	0.627	0.010	72.018	0.352	0.030
TMNG4635	Aitape-Barida 2	1.305	0.001	31.479	0.055	0.068
TMNG4636	Aitape-Barida 2	1.164	0.090	65.410	0.826	0.044
TMNG4637	Aitape-Barida 2	0.577	0.007	98.232	0.219	0.035
TMNG4638	Aitape-Barida 2	2.657	0.629	64.680	1.335	0.043
TMNG4639	Aitape-Barida 2	0.014	0.094	38.226	0.674	0.040
TMNG4640	Aitape-Barida 2	0.000	0.000	73.620	0.007	0.040
TMNG4641	Aitape-Barida 2	0.000	0.000	84.394	0.129	0.032
TMNG4642	Aitape-Barida 2	0.000	0.000	42.379	0.037	0.037
TMNG4645	Aitape-Barida 2	0.000	0.000	1.205	0.006	0.071
TMNG4646	Aitape-Barida 2	0.027	0.002	75.520	0.034	0.032
TMNG4647	Aitape-Barida 2	0.008	0.001	20.168	0.516	0.041
TMNG4648	Aitape-Barida 2	0.007	0.002	25.404	0.155	0.052

Appendix 13.3: *Continued.*

Sherd ID	Chemical group assignment	Reference group membership probability				
		Serra Hills	Aitape-Barida 1	Aitape-Barida 2	Aitape-Barida 3	Buamunding
TMNG4649	Aitape-Barida 2	1.347	0.053	55.102	0.009	0.039
TMNG4651	Aitape-Barida 2	0.008	0.016	96.284	1.008	0.027
TMNG4654	Aitape-Barida 2	0.003	1.342	31.224	0.665	0.027
TMNG4655	Aitape-Barida 2	0.000	0.001	85.883	0.299	0.031
TMNG4656	Aitape-Barida 2	0.000	0.337	76.263	0.267	0.033
TMNG4657	Aitape-Barida 2	0.000	0.000	75.474	0.132	0.033
TMNG4658	Aitape-Barida 2	0.000	0.000	57.688	0.093	0.048
TMNG4659	Aitape-Barida 2	0.000	0.000	15.481	0.063	0.029
TMNG4660	Aitape-Barida 2	0.000	0.000	73.481	0.029	0.026
TMNG4661	Aitape-Barida 2	0.000	0.000	17.919	0.085	0.018
TMNG4662	Aitape-Barida 2	0.000	0.000	6.070	0.002	0.042
TMNG4663	Aitape-Barida 2	0.274	0.000	41.054	0.005	0.029
TMNG4664	Aitape-Barida 2	0.000	0.000	84.155	0.136	0.033
TMNG4665	Aitape-Barida 2	0.000	0.000	84.334	0.100	0.024
TMNG4666	Aitape-Barida 2	0.371	0.000	4.759	0.022	0.033
TMNG4667	Aitape-Barida 2	0.000	0.000	42.052	0.043	0.026
TMNG4669	Aitape-Barida 2	0.001	0.076	22.540	0.016	0.040
TMNG4670	Aitape-Barida 2	0.000	0.002	79.400	0.032	0.027
TMNG4671	Aitape-Barida 2	0.000	0.000	36.889	0.001	0.029
TMNG4672	Aitape-Barida 2	0.000	0.000	10.632	0.058	0.018
TMNG4673	Aitape-Barida 2	0.000	0.000	7.882	0.002	0.032
TMNG4674	Aitape-Barida 2	0.223	0.000	5.926	0.011	0.054
TMNG4675	Aitape-Barida 2	0.001	0.000	24.197	0.002	0.047
TMNG4650	Aitape-Barida 2	0.063	0.026	2.103	0.618	0.046
TMNG4652	Aitape-Barida 2	0.000	0.267	7.740	0.974	0.081
TW16918	Aitape-Barida 2	0.047	0.007	6.173	0.068	0.023
AT649B10	Aitape-Barida 3	0.038	6.084	0.027	71.862	0.025
AT649B13	Aitape-Barida 3	0.002	0.002	0.000	21.567	0.028
AT649B1B	Aitape-Barida 3	0.001	0.002	0.000	5.046	0.028
AT649B2B	Aitape-Barida 3	0.271	0.006	0.000	54.347	0.029
AT649B3	Aitape-Barida 3	2.791	0.000	0.000	10.148	0.047
AT649B4	Aitape-Barida 3	0.438	0.059	0.000	94.285	0.035
AT649B6	Aitape-Barida 3	0.086	0.000	0.000	50.285	0.036
AT649B7	Aitape-Barida 3	2.390	0.026	0.000	28.348	0.033
AtNG1601	Aitape-Barida 3	0.054	0.007	0.000	68.697	0.080
AtNG1602	Aitape-Barida 3	0.031	0.013	0.000	74.013	0.042
AtNG1603	Aitape-Barida 3	0.518	5.048	0.004	60.902	0.035
AtNG1604	Aitape-Barida 3	2.172	0.102	0.000	94.665	0.051
AtNG1605	Aitape-Barida 3	7.763	17.692	0.000	88.404	0.045
AtNG1608	Aitape-Barida 3	0.063	1.882	0.000	69.154	0.043
AtNG1609	Aitape-Barida 3	0.008	0.454	0.000	12.827	0.033
AtNG1610	Aitape-Barida 3	4.442	0.110	0.001	12.628	0.033
AtNG1612	Aitape-Barida 3	15.844	8.048	0.000	53.098	0.038
AtNG1614	Aitape-Barida 3	5.759	0.559	0.000	57.639	0.030
AtNG1615	Aitape-Barida 3	0.038	9.557	0.000	37.566	0.028
ATNG16A	Aitape-Barida 3	0.226	0.013	0.000	16.643	0.040
AtNG2302	Aitape-Barida 3	0.968	0.001	0.000	73.044	0.045
AtNG2303	Aitape-Barida 3	3.963	0.007	0.000	18.431	0.044
AtNG2305	Aitape-Barida 3	11.625	0.004	0.000	18.025	0.064
AtNG2306	Aitape-Barida 3	0.866	0.504	0.000	62.789	0.051
AtNG2307	Aitape-Barida 3	0.043	0.072	0.000	52.017	0.050
AtNG2310	Aitape-Barida 3	1.522	0.515	0.000	43.845	0.033
ATNG23A	Aitape-Barida 3	0.559	0.006	0.001	91.505	0.049
ATNG23B	Aitape-Barida 3	0.011	0.000	0.000	20.364	0.082
TM0013	Aitape-Barida 3	0.014	11.278	0.001	32.523	0.007
TM002	Aitape-Barida 3	0.002	0.241	2.226	9.831	0.024
TMNG46D	Aitape-Barida 3	0.000	0.531	0.001	5.660	0.066
WL16110	Buamunding reference	0.001	0.005	0.000	0.000	69.627
WL16111	Buamunding reference	0.008	0.003	0.000	0.000	99.501
WL16112	Buamunding reference	0.001	0.005	0.000	0.000	64.712
WL1611A	Buamunding reference	0.000	0.000	0.000	0.000	3.661
WL1611B	Buamunding reference	0.002	0.002	0.000	0.000	69.976
WL1613B	Buamunding reference	0.000	0.000	0.000	0.000	22.290
WL1614	Buamunding reference	0.000	0.000	0.000	0.000	8.966

Appendix 13.3: *Continued.*

Sherd ID	Chemical group assignment	Reference group membership probability				
		Serra Hills	Aitape-Barida 1	Aitape-Barida 2	Aitape-Barida 3	Buamunding
WL1615	Buamunding reference	0.000	0.000	0.000	0.000	40.313
WL1616	Buamunding reference	0.009	0.000	0.000	0.000	66.109
WL1617	Buamunding reference	0.001	0.003	0.000	0.000	59.413
WL1618	Buamunding reference	0.000	0.013	0.000	0.000	0.317
WL1619	Buamunding reference	0.000	0.000	0.000	0.000	40.829
RM1561B	Ramu	29.442	11.549	1.909	1.254	0.041
RM1562A	Ramu	10.491	0.200	0.403	0.020	0.077
RM1562B	Ramu	12.816	26.778	0.289	0.271	0.052
RM1563	Ramu	61.750	1.196	0.001	0.119	0.064
RM1564	Ramu	12.582	1.004	0.003	0.043	0.070
RM1565	Ramu	5.212	3.502	0.009	2.772	0.051
RM1566	Ramu	52.267	3.658	0.056	0.177	0.046
KP001	Kaiep	16.714	0.016	0.000	0.095	0.039
KP003	Kaiep	19.566	0.009	0.017	0.028	0.038
KP004	Kaiep	0.001	0.000	0.000	0.183	0.044
KP005	Kaiep	0.000	0.000	0.000	0.001	0.035
KP006	Kaiep	0.006	0.000	0.000	0.023	0.035
KP007	Kaiep	0.010	0.056	0.016	0.107	0.039
KP200	Kaiep	0.004	0.003	0.000	0.002	0.069
WN001	Wanigela	0.007	0.089	0.528	0.001	0.033
WN002	Wanigela	0.000	0.001	4.107	0.000	0.035
WN003	Wanigela	0.000	0.000	0.346	0.000	0.022
WN004	Wanigela	0.000	0.000	0.061	0.000	0.030
WN005	Wanigela	0.000	0.001	3.417	0.000	0.026
WN007	Wanigela	0.000	0.000	0.218	0.000	0.023
WN008	Wanigela	0.000	0.000	0.000	0.000	0.018
WN009	Wanigela	0.000	0.000	0.000	0.000	0.016
BA001	New Britain	0.000	0.000	0.000	0.000	0.017
BA002	New Britain	0.000	0.000	0.000	0.000	0.021
BA005	New Britain	0.000	0.000	0.000	0.000	0.023
BA006	New Britain	0.005	0.000	0.000	0.000	0.023
BA003	Manus Island	0.000	0.000	0.000	0.000	0.011
TW1551B	Unassigned	13.866	0.061	0.000	0.000	0.026
WL1621B	Unassigned	5.072	1.740	0.000	21.951	0.108
ALI641	Unassigned	0.000	0.000	0.723	0.012	0.020
AT649B5	Unassigned	0.003	0.005	0.000	0.195	0.047
AT649B8	Unassigned	84.744	31.674	2.727	1.967	0.043
AT649B11	Unassigned	2.429	0.000	0.000	1.369	0.043
ATNG1613	Unassigned	0.000	0.128	0.003	0.006	0.010
AtNG2304	Unassigned	1.204	0.000	0.000	0.008	0.029
LT6014	Unassigned	2.147	4.953	0.009	0.624	0.077
LT6031A	Unassigned	0.000	0.000	0.000	0.000	0.046
SR60813	Unassigned	0.000	0.485	0.000	0.000	0.007
TM1772	Unassigned	0.000	0.163	0.000	0.008	0.020
TM1791	Unassigned	2.048	18.744	0.103	33.824	0.039
TM17912	Unassigned	0.001	0.015	0.081	0.567	0.020
TM17913	Unassigned	0.000	0.010	0.426	0.076	0.029
TM1792	Unassigned	6.631	1.201	0.071	8.250	0.031
TM17921	Unassigned	0.018	33.715	20.673	14.360	0.023
TM1799	Unassigned	0.000	0.000	0.034	0.013	0.010
TMNG4603	Unassigned	0.000	0.000	0.000	0.003	0.019
TMNG4643	Unassigned	0.000	0.155	0.000	0.000	0.085
TMNG4653	Unassigned	0.083	39.666	35.352	7.588	0.069
TMNG4668	Unassigned	0.000	0.005	0.007	0.042	0.019
TMNG46B	Unassigned	0.000	0.258	0.033	0.670	0.024
TMNG46C	Unassigned	0.000	1.568	0.000	2.042	0.029
TW15310	Unassigned	0.018	0.000	0.000	0.018	0.120
TW15311	Unassigned	0.072	0.000	0.000	0.061	0.032
TW15312	Unassigned	3.255	0.000	0.000	0.006	0.019
TW1531A	Unassigned	0.000	0.000	0.000	0.000	0.046
TW1531B	Unassigned	0.001	0.000	0.000	0.000	0.063
TW1532A	Unassigned	0.000	0.000	0.000	0.006	0.069
TW1532B	Unassigned	0.017	0.000	0.000	0.000	0.022
TW1533	Unassigned	0.031	0.000	0.201	0.006	0.021
TW1534	Unassigned	0.011	0.000	0.000	0.000	0.052
TW1535	Unassigned	0.000	0.000	0.000	0.000	0.052

Appendix 13.3: *Continued.*

Sherd ID	Chemical group assignment	Reference group membership probability				
		Serra Hills	Aitape-Barida 1	Aitape-Barida 2	Aitape-Barida 3	Buamunding
TW1536	Unassigned	0.002	0.000	0.000	0.000	0.122
TW1537	Unassigned	1.986	0.000	0.005	0.000	0.018
TW1539	Unassigned	0.001	0.000	0.000	0.054	0.101
TW1542	Unassigned	0.438	0.000	0.000	0.000	0.029
TW1552	Unassigned	0.002	0.000	0.000	0.000	0.038
TW1691	Unassigned	0.000	0.000	0.000	0.000	0.028
TW16910	Unassigned	0.012	0.000	0.000	0.001	0.033
TW16916	Unassigned	0.073	0.000	0.000	0.000	0.027
TW16917	Unassigned	0.001	0.000	0.000	0.000	0.020
TW1692	Unassigned	0.002	0.000	0.000	0.000	0.076
TW1695	Unassigned	8.356	0.039	0.000	0.016	0.056
TW1701	Unassigned	0.040	0.002	0.000	0.000	0.053
TW1702	Unassigned	0.034	0.000	0.000	0.000	0.057
TW1711A	Unassigned	3.037	0.062	0.003	0.000	0.032
TW1711B	Unassigned	0.000	0.000	0.000	0.000	0.018
TW1712A	Unassigned	0.000	0.027	0.000	0.000	0.048
TW1712B	Unassigned	0.134	0.000	0.000	0.001	0.023
TW1713	Unassigned	0.064	0.000	0.003	0.000	0.017
TW1714	Unassigned	0.792	0.000	0.000	0.002	0.030
TW1761	Unassigned	0.001	0.000	0.000	0.005	0.109
TW1762	Unassigned	0.000	0.032	0.000	0.010	0.016
WL1612B	Unassigned	1.254	0.001	0.005	0.000	0.040
WL1613A	Unassigned	0.037	0.242	0.000	0.728	0.126
WL1621A	Unassigned	1.965	0.000	0.000	0.001	0.167
WL1622A	Unassigned	0.029	0.000	0.000	0.001	2.940
WL1622B	Unassigned	6.219	0.026	0.000	0.222	0.113
WL1623	Unassigned	7.753	1.801	0.000	6.076	0.097
WL163B1	Unassigned	0.433	0.000	0.000	0.001	0.036
WL163B2	Unassigned	0.222	0.003	0.000	0.062	0.321
WM6155	Unassigned	0.000	0.033	0.024	0.523	0.046

Appendix 13.4: Obsidian Artifacts from the Sepik Coast, Papua New Guinea

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Introduction

The analyzed collection of more than 3,000 pieces of obsidian consists mainly of débitage or debris, with an occasional retouched piece. Although this is mainly a surface collection, the integrity of these pieces is intact, and there is little edge damage from lateral or vertical movement. Thus, analysis as to their production, reduction, and use was worthwhile, even though they were recovered primarily from surface contexts.

General Characteristics of the Assemblages

No matter where the obsidian was found, on the Sepik coast or on the nearby islands such as Tarawai, the vast majority of these artifacts can be classified as debris, or chips. In standard analytical terminology, debris consists of flakes less than 20 mm; débitage comprises pieces large enough to be made into tools, or at the very least, large enough to be potentially functionally useful. More than 97% of the artifacts analyzed are debris. The remaining 3% are retouched flakes and flake cores as well as one tiny stemmed point. The majority of flakes are no larger than ~30 × 20 mm, with a range from 20 × 20 mm to 60 × 40 mm.

It is clear that the obsidian source pieces from which these flakes were derived were quite small, within the size range termed a pebble in geology (between 4 and 64 mm maximal length); their size was further reduced by removing flakes haphazardly when cutting implements were needed. If correct, then this inference suggests that when the source material arrived on the Sepik coast or nearby islands, it consisted of small, mostly preworked forms since flakes displaying cortex are rare or absent. It is certain that nodules were tested for flaking quality (e.g., presence of internal flaws, large phenocrysts, etc.) at the geological sources or quarries, be it on New Britain or Lou/Pam Lin in the Admiralty Islands. After the blocks or preforms were exported, the obsidian knappers used one or the other of two methods to reduce the transported obsidian into cores—handheld direct percussion using a hard hammer (a rock) or the bipolar technique, which results in an entirely different blank and core typology.

When the bipolar technique is used, the knapper places the pebble on an anvil, such as a slab of rock (*sur enclume* in French) or any hard surface, such as tamped earth, a tree limb, etc., and strikes the pebble from above, removing a flake but shattering the bottom of the pebble. The resulting flake retains some evidence of this shattering on its distal end. This method is usually used in sequence after other types of reduction, that is, after the core had been reduced to a size where holding of the piece by hand would be risky. Even so, there are almost no incidences of series of removals from these resulting flake cores. That is, a flake might be removed from one or two core surfaces, but further reduction was not done.

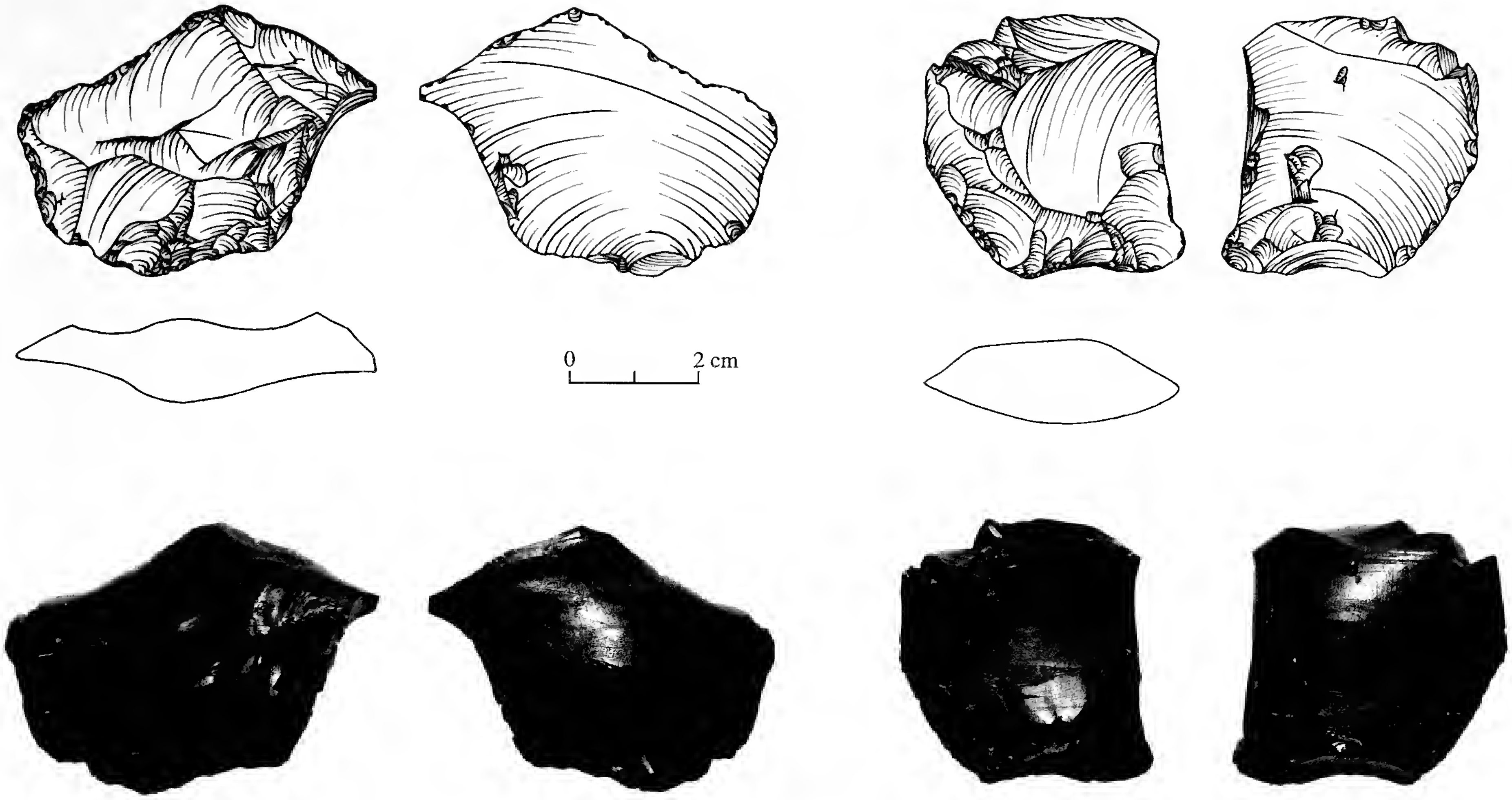
The retouched flakes are mainly triangular in shape, with both lateral edges deliberately retouched (Appendix Fig. 13.4.1). Only a few retouched pieces (65) have been identified, mainly from Tarawai, but they do occur also in small numbers on the Sepik mainland—they are always the larger flakes rather than chips or debris. Some edge damage was observed on several of the pieces, mainly on the distal end (the tip). Retouch was obviously done to blunt the lateral edges of the flakes, presumably because they were to be handheld, and without the retouch, the user would have cut through the user's hand or fingers. This implies that the distal end was the functional element of these flakes. If so, then the observed use damage indicates that the material being worked with these flakes, such as wood or other plant material, was softer than obsidian. There are no identifiable scrapers in these assemblages, implying that these retouched flakes were used for cutting, carving, or slicing. Although chert was also available for tool manufacture, the material I have observed is poor for knapping, with many inclusions, prohibiting the production of usable flakes.

Blades or bladelets are absent from the studied assemblages. When bladelet dimension scars (e.g., at least twice as long as wide) are observed on cores, they are certainly knapping accidents; there are no flakes with bladelet dimensions in the débitage, except for a small (20.2 × 8.5 × 3.2 mm) point recovered at Yundabubu Garden (ABLP 173) on Tarawai Island (Appendix Fig. 13.4.2). This stemmed or tanged point is triangular in shape, with both lateral edges retouched by direct percussion to form a point at the distal end. At the proximal end, two inverse notches form the stem, part of which is broken. This is the only point found in this entire Sepik coast assemblage.

To summarize, the obsidian in these assemblages was likely used for specific purposes—cutting or slicing meat, wood, and other plant material—and possibly in rituals where cutting might be important, such as circumcision, scarification, or tattooing, as is the case ethnographically on New Britain (Specht, 1981), and possibly has been since pre-Lapita times (Kononenko & Torrence, 2009). As noted, these assemblages contain mostly tiny pieces. Since obsidian is so sharp, even a small edge can be useful for slicing or cutting, and such activities, for example, on skin, would not have produced significant amounts of edge damage on chips and flakes, implying that, when present, the observed retouch does not indicate how these pieces were actually used—smaller flakes may have been utilized briefly for cutting or slicing, after which they were discarded. Several indications gleaned from the nature of these assemblages imply that obsidian was a valuable commodity in these societies. Whether it was a prestige commodity used for ritual activities performed directly on a person or for carving ritual objects is indeterminable, but it is clear that cutting and slicing are the most likely uses for these small artifacts.

Implications for Transport

In their initial publication based on obsidian collected during the A. B. Lewis archaeological surveys, Terrell and Welsch



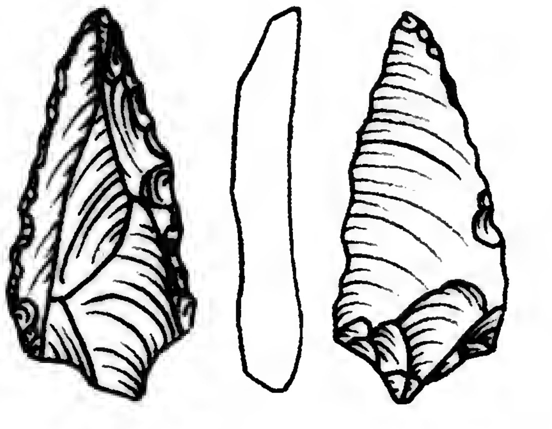
Appendix Fig. 13.4.1. Retouched obsidian flakes collected at Yundabubu Garden (ABLP 173), Tarawai Island.

suggested two apparent trends in the distribution of obsidian along the coast—first, that material suspected to be early in age (from Kobom/Airati) was on average heavier than that collected at more recent find spots in the Aitape area (ABLP 160 and ABLP 650) and Ali Island (excepting Tubungbale), and, second, that material collected in the Wewak area (Tarawai, Walis, Karesau, and Muschu) nearer to the sources of obsidian in the Bismarck Archipelago was on average heavier than material farther west along the coast at Aitape and Kobom. As they wrote:

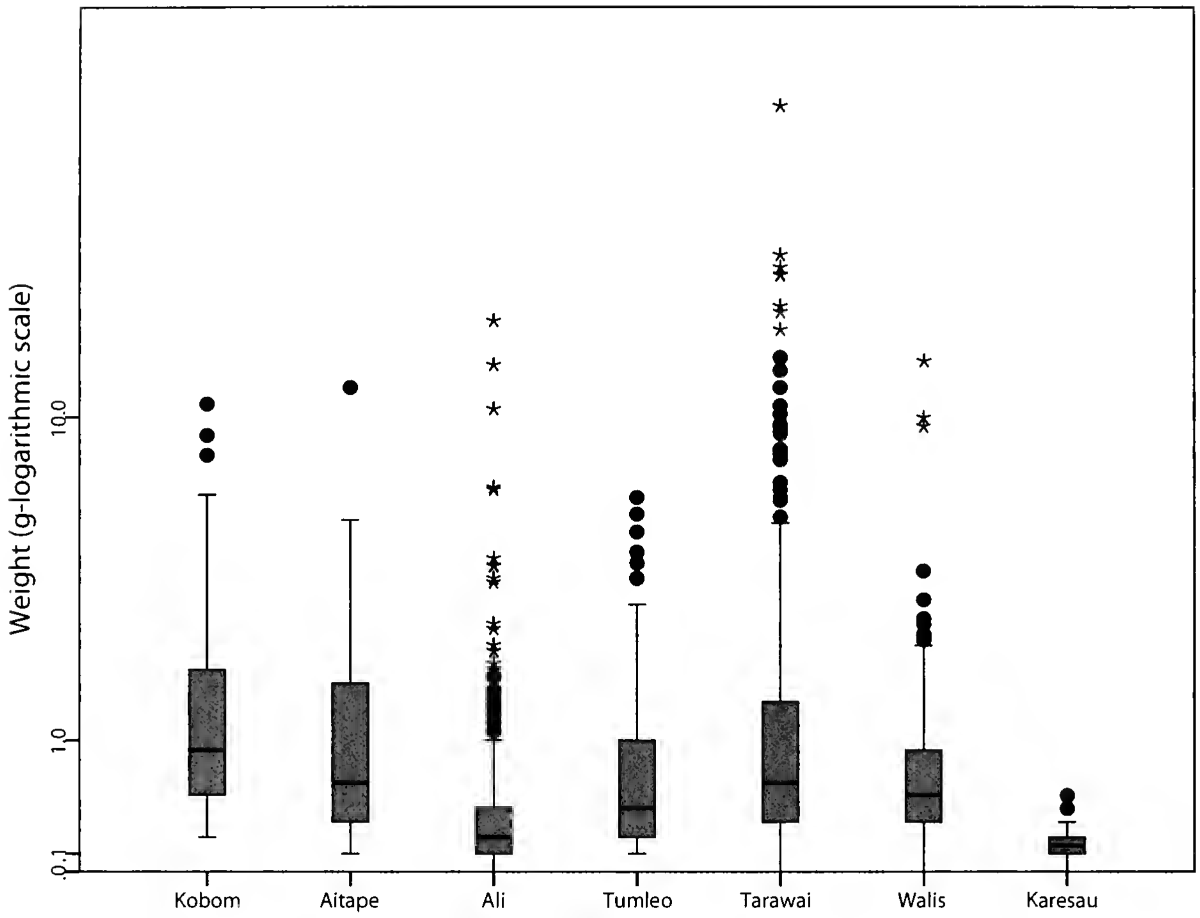
> The observed difference between the average size (weight) of obsidian flakes found at Kobom on the mainland and from seemingly more recent sites on Ali Island contrasts with the similarity of the Kobom specimens in this respect to those from the Wewak area sites (which are closer to the Bismarck Archipelago) may show that people in the Aitape area were once more directly connected to the Bismarck Archipelago than they were later in prehistory. (Terrell & Welsch, 1997, p. 562)

The present analysis, which includes material from the 1996 archaeological surveys and excavations, allows reevaluation of these earlier interpretations. Terrell and Welsch (1997) reported mean and standard deviation values for the 1993 assemblages. However, inspection of weight distributions across assemblages indicates that the weights are strongly positively skewed—that is, as noted, the majority of pieces are small flakes, chips, and debris, with only a small number of heavier or larger pieces.

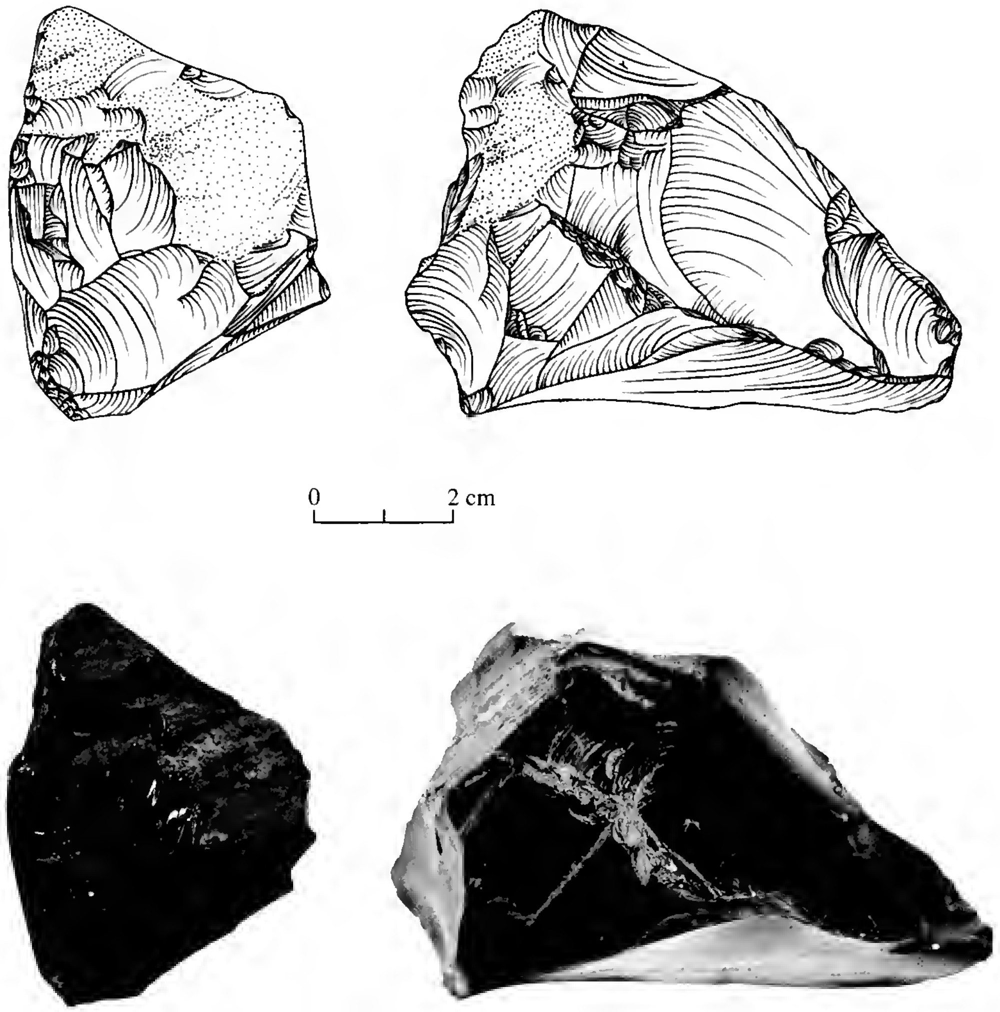
Use of nonparametric box-and-whisker plots (Appendix Fig. 13.4.3) indicates in particular that the distance falloff noted by Terrell and Welsch is not as clear-cut as they suggested. Median values for most assemblages are roughly comparable, particularly those from which large sample sizes are available, such as Aitape, Kobom, Tumleo, Tarawai, and Walis. Many of the observed differences in mean weight noted



Appendix Fig. 13.4.2. Obsidian point collected at Yundabubu Garden (ABLP 173), Tarawai Island.



Appendix Fig. 13.4.3. Box-and-whisker plot of obsidian weights pooled by regional context.



Appendix Fig. 13.4.4. Obsidian core collected at Simir Rai (ABLP 143), Tarawai Island.

by Terrell and Welsch are an artifact of differential numbers of larger pieces at individual sites. Total volume of material is likely to be a more reliable guide to relative availability of obsidian than average weight (e.g., Sheppard, 1993, p. 127). However, as most of the studied assemblages are surface collections, it is unclear how best to calculate meaningful volumetric comparisons between assemblages.

Several assemblages on Tarawai Island stand out as the only assemblages that contain larger cores (Appendix Fig. 13.4.4). This might suggest that Tarawai Island was an important node in the prehistoric networks through which obsidian was transported from the Bismarcks to the Sepik coast—for instance, in ethnographic times, Manus traders transported Admiralty obsidian as far west as the Schouten Islands and even Wewak (Ambrose, 1976, p. 358), where Tarawai Islanders may have then acquired it.

Conclusion

The nature of obsidian is such that it has a special character in terms of slicing or cutting. Obsidian from other parts of the world, such as the Near East, was also traded or exchanged, over large distances for purposes similar to those proposed above. It is clear to me that the movement of this material over ~800 km from sources on New Britain or ~500 km from the Admiralty sources through Tarawai Island to the wider Sepik coast indicates a social network of exchange of obsidian quite like the one that Golitko (Chapter 13) proposes based on his chemical analyses of ceramics. To paraphrase Golitko, at no time were people on the Sepik coast ever isolated from their island neighbors in the Bismarck Archipelago or the Admiralty Islands. Whether the exchange of commodities was for an economic or a ritual purpose, or both, is immaterial. As a mechanism for bringing people into an "interaction" sphere, the exchange of stones, ceramics, and so on is integral to developing social networks crosscutting ethnicity, religion, and distance.

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Chapter 14: Analysis of Chronological Parameters for the Aitape District Pottery Sequence

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Abstract

Radiocarbon determinations suggest that the earliest pottery thus far identified on the Sepik coast, which we have called Nyapin Ware after a locality on Tumleo Island, dates back to the interval 2,000–1,500 BP (95% highest posterior density [HPD]). A more precise estimate can be made for the Sumalo Ware as currently known in the Aitape area. Analysis suggests that Sumalo Ware was locally in use over a period of between 5 and 270 years (95% HPD) beginning some time in the interval 1,400–1,200 BP (95% HPD). Additionally, a local marine ΔR of 1,005 ± 80 can be estimated for this location.

Introduction

This report presents an analysis of 11 radiocarbon determinations obtained for material in association with pottery from the Aitape district pottery sequence. The purpose of this analysis is primarily to provide chronological parameters for the Nyapin and Sumalo pottery wares (for descriptions of these wares, see Chapter 7). This is complicated to some extent by the fact that the dated material associated with Nyapin Ware derives solely from a marine reservoir for which no suitable reservoir corrections exist. Thus, a secondary outcome from this analysis is an estimated marine ΔR (marine reservoir correction) for this location. The analysis has been performed using a Bayesian inference model as described in the analysis section below. The key model assumptions made during this analysis are (1) the local marine ΔR is unknown but can be validly referenced to the standard INTCAL1998 marine calibration data via a constant offset common to both locations from which samples have been derived; (2) no significant offset from the INTCAL1998 terrestrial calibration data is required for this location; (3) the sequence Nyapin Ware (oldest) = 1, Sumalo Ware = 2, Aiser Ware = 3, and Wain Ware = 4 describes a chronologically coherent abutting ware sequence (Chapter 7); and (4) the available radiocarbon determinations are a random sample from the total archaeological record (primarily unobserved, unexcavated, and undated) for this cultural sequence.

Analysis

The Bayesian calibration applied in this analysis follows the phase model described by Nicholls and Jones (1998, 2001) as implemented in DateLab 1.2 (Jones & Nicholls, 2002). All dates are treated as coming from one of a number of ware phases that occur as a single series. Within ware phases, there are no prior constraints on the relative age of any of the dates. However, we know a priori the relative ordering of the wares and add a further constraint that there is no overlap of the ware phases. The purpose of this analysis is to estimate the date (θ) at which the events occurred and to provide age estimates for the period of activity within which the dated events took place (ψ) on the basis of the measured CRA (conventional radiocarbon age before 1950) data and ware associations given in Table 14.1.

For further discussion of the model applied in the current analysis, it is necessary to define the following notation. Dates are regarded as arising from a single series of M abutting phases. N_m radiocarbon age determinations are gathered from phase m, making $K \equiv \Sigma N_m$ dates in all. For $n \in \{1, 2 \ldots N_m\}$, let $y_{m,n}$ denote the value of the nth radiocarbon age measured in the mth phase, reported with associated standard error $\sigma_{m,n}$. For all quantities $X_{m,n}$, let X denote the corresponding vector in the natural ordering, so that $y \equiv (y_{1,1}, \ldots, y_{M,NM})$ etc. Let $\theta_{m,n}$ be a calibrated date for specimen (m, n), with units calendar years AD and assumed to equal the context date associated with the (m, n)th specimen. For $m \in \{0, 1 \ldots M\}$, let ψ_m denote the boundary date at the lower boundary of phase m. We have a total $K + M + 1$ unknown parameters: the $M + 1$ layer boundary dates $\psi_0 \ldots \psi_M$, and the K unknown object dates $\theta_{1,1,} \ldots \theta_{M,NM}$. Let P and A, $P \leq A$, be given termini, setting lower and upper bounds on the dates. Possible parameter sets (ψ, θ) take some value in a parameter space Ω. This space is simply the set of all states (ψ, θ) satisfying the stratigraphic constraints. In the current analysis we have

$$\Omega \equiv \{(\psi,\theta);\ P \leq \psi/m/ \leq \theta/m/,. \leq \psi/m-1/., \leq \theta/m-1/,. \leq \ldots \leq \psi 1 \leq \theta_{1},. \leq \psi 0 \leq A\},$$

where $P = 2{,}939$ and $A = 398$, approximating ∞ and 0 years BP respectively. Here we seek to estimate the parameters Ψ

TABLE 14.1. Chronometric data used in the current analysis.[a]

Lab	ID	Provenience	CRA	Error	Reservoir	Ware	Test pit	Square	Layer/spit	Site	Location	Phase
ISGS	3652	NGRP-23/2D/B	1,370	70	terrestrial	Sumalo	23	2D	B	23	Aitape	2
ISGS	3656	recount of #3652	1,320	70	terrestrial	Sumalo	23	2D	B	23	Aitape	2
Beta	105671	same sample as 3652 and 3656	1,260	50	terrestrial	Sumalo	23	2D	B	23	Aitape	2
ISGS	3667	NGRP-23/2E/B	1,300	70	terrestrial	Sumalo	23	2E	B	23	Aitape	2
ISGS	3668	NGRP-23/2A/C	1,330	70	terrestrial	Sumalo	23	2A	C	23	Aitape	2
ISGS	5329	NGRP-46/1/A/4/2	2,660	70	marine[b]	Sumalo	46	1A	4/2	46	Tumelo	2
ISGS	5330	NGRP-46/2/2/5	3,130	70	marine[c]	Nyapin	46	2	2/5	46	Tumelo	1
ISGS	5331	NGRP-46/2/2/4	3,250	70	marine[d]	Nyapin	46	2	2/4	46	Tumelo	1
ISGS	5332	NGRP-46/1/A/2/2	2,540	70	marine[e]	Aiser	46	1A	2/2	46	Tumelo	3
ISGS	3654	NGRP-46/1/A/4/1	1,380	90	terrestrial	Sumalo	46	1A	4/1	46	Tumelo	2
ISGS	3671	NGRP-46/1/A/3/3	1,320	90	terrestrial	Sumalo	46	1A	3/3	46	Tumelo	2

[a] CRA = conventional radiocarbon age before 1950.
[b] *Geloina erosa*, 10.1 gm, and *Anadara granosa*, *Periglypta reticulata*, *Conus litteratus*, 42.3 gm.
[c] *Anadara granosa*, *A. antiquata*, 44.3 gm.
[d] *Anadara granosa*, 69.2 gm.
[e] *Batissa* sp., *Batissa a. albertisii*, *Anadara granosa*, 74.8 gm.

and θ on the basis of the chronometric data and ware associations given in Table 14.1. Following the standard Bayesian inferential framework, the posterior distribution of Ψ and θ conditional on the observed dates y (with density $h(\Psi, \theta \mid y)$) is defined in terms of an unnormalized prior density $f(\Psi, \theta)$ and likelihood $L(y \mid \theta)$ as

$$h(\theta,\Psi \mid y) = L(y \mid \theta) \times f(\Psi,\theta).$$

Here we use the noninformative prior $f(\Psi, \theta)$ defined by Nicholls and Jones (1998, 2001). Observations are assumed independent, so the joint likelihood, $L(y \mid \theta)$, is

$$L(y \mid \theta) = \prod_{m=1}^{M} \prod_{n=1}^{Nm} \ell(y_{m,n} \mid \theta_{m,n}).$$

The likelihood $l(y \mid \theta))$ calculated here (this corresponds to the calibrated distribution) follows the standard definition of the radiocarbon likelihood (e.g., Buck et al., 1991). In the current analysis, the observation model for CRA y_i is

$$y_i \sim \mathrm{N}(\mu(\theta_i), \sigma(\theta_1)^2) + R,$$

where $\sigma(\theta_i)^2 \equiv \sigma(\theta_i)_\mu{}^2 + \sigma_i^2$ and $R \sim N(\delta, \sigma_\delta{}^2)$. Here $\mu(\theta_i)$ and $\sigma(\theta_i)_\mu$ are standard, empirically determined radiocarbon calibration functions (e.g., Stuiver et al., 1998), and R is a reservoir offset (e.g., Stuiver & Braziunas, 1993).

In the current analysis, the INTERCAL98 calibration data (Stuiver et al., 1998) were used, and calibration curves were interpolated using a spline such that $\mu(\theta_i)$ and $\sigma(\theta_i)_\mu$ are functions piecewise linear by year. Here no terrestrial reservoir offset has been applied. In the analysis conducted, the marine reservoir offset is unknown and thus a priori can fall anywhere in the interval $[-\infty, \infty]$. As a result, the calibrated distribution for the samples deriving from a marine reservoir cannot be calculated in the current analysis. However, the posterior distributions for these samples (and the unknown marine reservoir offset) have been calculated in the Bayesian analysis described below following the approach defined by Jones et al. (2007). In this case, correlated reservoir offsets have been used (Jones & Nicholls, 2001).

Following the definitions given above, the likelihood $(\ell(y_i \mid \theta_i))$ is distributed as:

$$\ell(y_i \mid \theta_i) = \frac{1}{\sigma(\theta_i)\sqrt{2\pi}} \exp\left(-(y_{m,n} - \mu(\theta_i) - R)^2 / 2\sigma(\theta_i)^2\right).$$

Results

Marginal posteriors for Ψ and θ were computed using an implementation of the Metropolis-Hastings Markov chain Monte Carlo sampler described by Nicholls and Jones (1998, 2001) through DateLab 1.2 (Jones & Nicholls, 2002). The sampling statistics are given in Table 14.2.

TABLE 14.2. Sampler details for the current analysis.

Sampler	Metropolis-Hastings
Sample size	20,000
Sampling interval	1,000
Burn size	1
Run duration	5,352
Random seed	682,707,884
Lower limit	398
Upper limit	2,939

TABLE 14.3. Summary posterior distributions for chronological phase parameters.[a]

Parameter	95% HPD	68% HPD
Nyapin start (Ψ_3)	2,790–1,675 (0.952)	2,320–1,755 (0.686)
Sumalo start (Ψ_2)	1,395–1,195 (0.957)	1,325–1,250 (0.679)
Sumalo end (Ψ_1)	1,285–1,080 (0.938)	1,265–1,170 (0.682)
Sequence duration (R)	5–270 (0.95)	5–120 (0.68)

[a] HPD = highest posterior density.

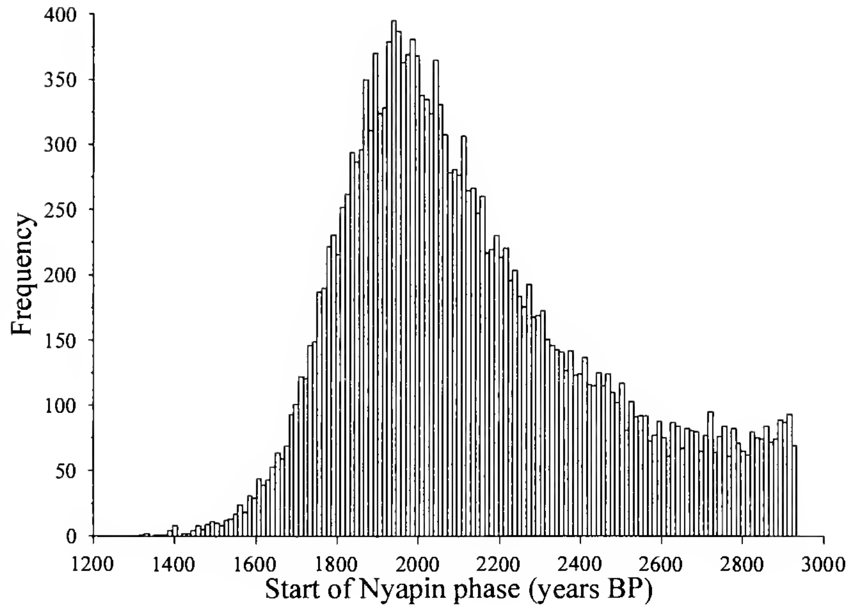

FIG. 14.1. Distribution for the start of Nyapin Ware.

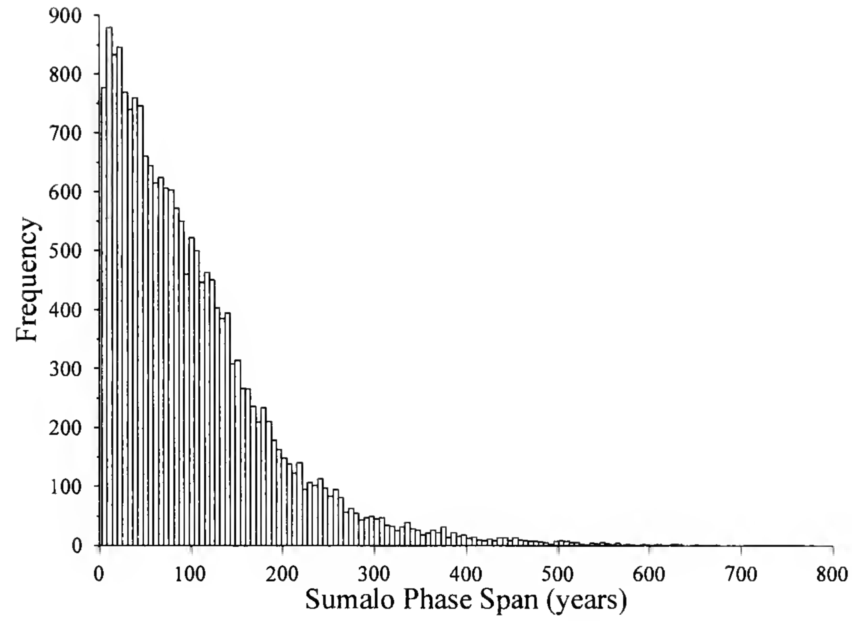

FIG. 14.4. Distribution for the span of the Sumalo Ware.

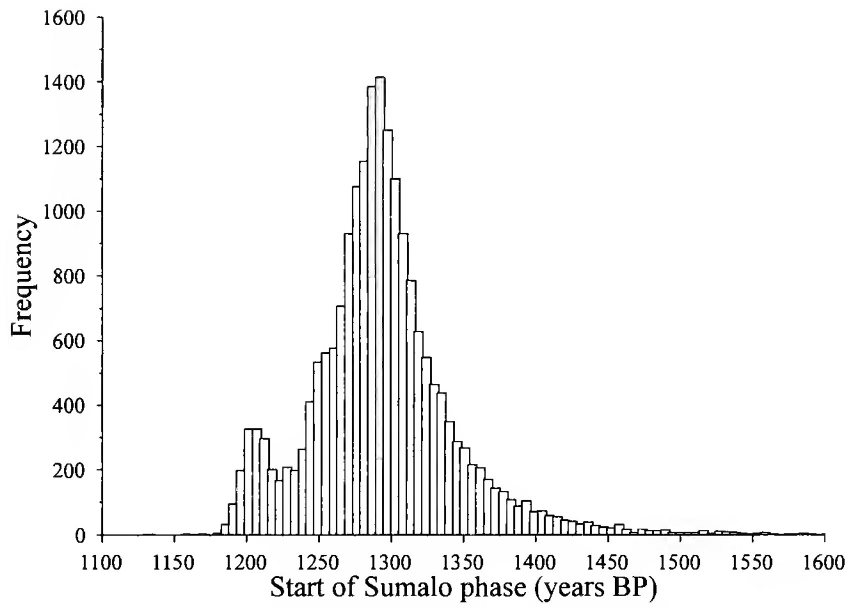

FIG. 14.2. Distribution for the start of Sumalo Ware.

Summary statistics for the posterior distributions of the dated events (θ_i) are presented. Additionally, following the inference model defined above, we can produce some posterior estimates for the span of the individual pottery wares. However, these will be usefully illustrative for the Sumalo component in the current analysis only due to the limited data associated with the other components. Thus we will define the chronological span of Sumalo Ware ($R = \Psi_2 - \Psi_1$) and distributions for the onset (Ψ_2) and termination (Ψ_1) of this phase and make an estimate of when the making of Nyapin Ware began (Ψ_3).

The posterior distributions for Ψ_1, Ψ_2, Ψ_3, and R are summarized in Table 14.3 and Figures 14.1–14.4, and the posterior distributions for the dated events are summarized in Table 14.4 and Figure 14.5. Additionally we can describe the posterior distribution for the local marine ΔR at this location as a normally distributed variable distributed as 1,005 ± 80 years (Fig. 14.6).

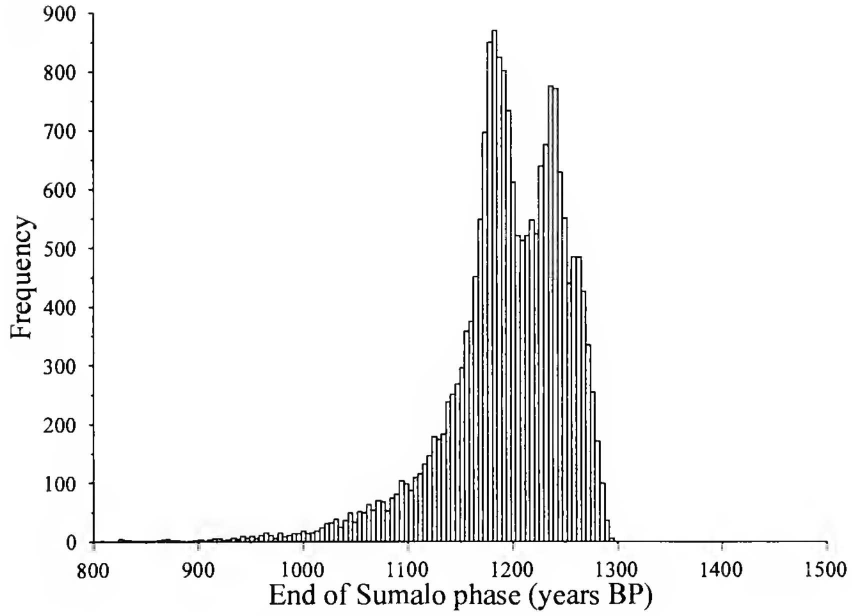

FIG. 14.3. Distribution for the end of Sumalo Ware.

TABLE 14.4. Summaries of the posterior distributions for θ.[a]

Sample	CRA	95% HPD	68% HPD
ISGS-3652	1,370 ± 70	1,320–1,170 (0.96)	1,200–1,185 (0.108); 1,290–1,230 (0.592)
ISGS-3656	1,320 ± 70	1,312–1,177 (0.946)	1,207–1,192 (0.106); 1,282–1,222 (0.585)
Beta-105671	1,260 ± 50	1,294–1,159 (0.959)	1,279–1,204 (0.706)
ISGS-3667	1,300 ± 70	1,297–1,162 (0.948)	1,207–1,192 (0.104); 1,282–1,222 (0.59)
ISGS-3668	1,330 ± 70	1,302–1,167 (0.95)	1,197–1,182 (0.098); 1,287–1,227 (0.604)
ISGS-5329	2,660 ± 70	1,322–1,142 (0.944)	1,202–1,187 (0.102); 1,292–1,217 (0.606)
ISGS-5330	3,130 ± 70	1,932–1,452 (0.949)	1,812–1,572 (0.675)
ISGS-5331	3,250 ± 70	2,070–1,560 (0.951)	1,935–1,695 (0.669)
ISGS-5332	2,540 ± 70	1,253–908 (0.956)	1,208–1,028 (0.672)
ISGS-3654	1,380 ± 90	1,329–1,179 (0.942)	1,299–1,224 (0.644)
ISGS-3671	1,320 ± 90	1,321–1,171 (0.947)	1,201–1,186 (0.104); 1,291–1,231 (0.572)

[a] CRA = conventional radiocarbon age before 1950; HPD = highest posterior density.

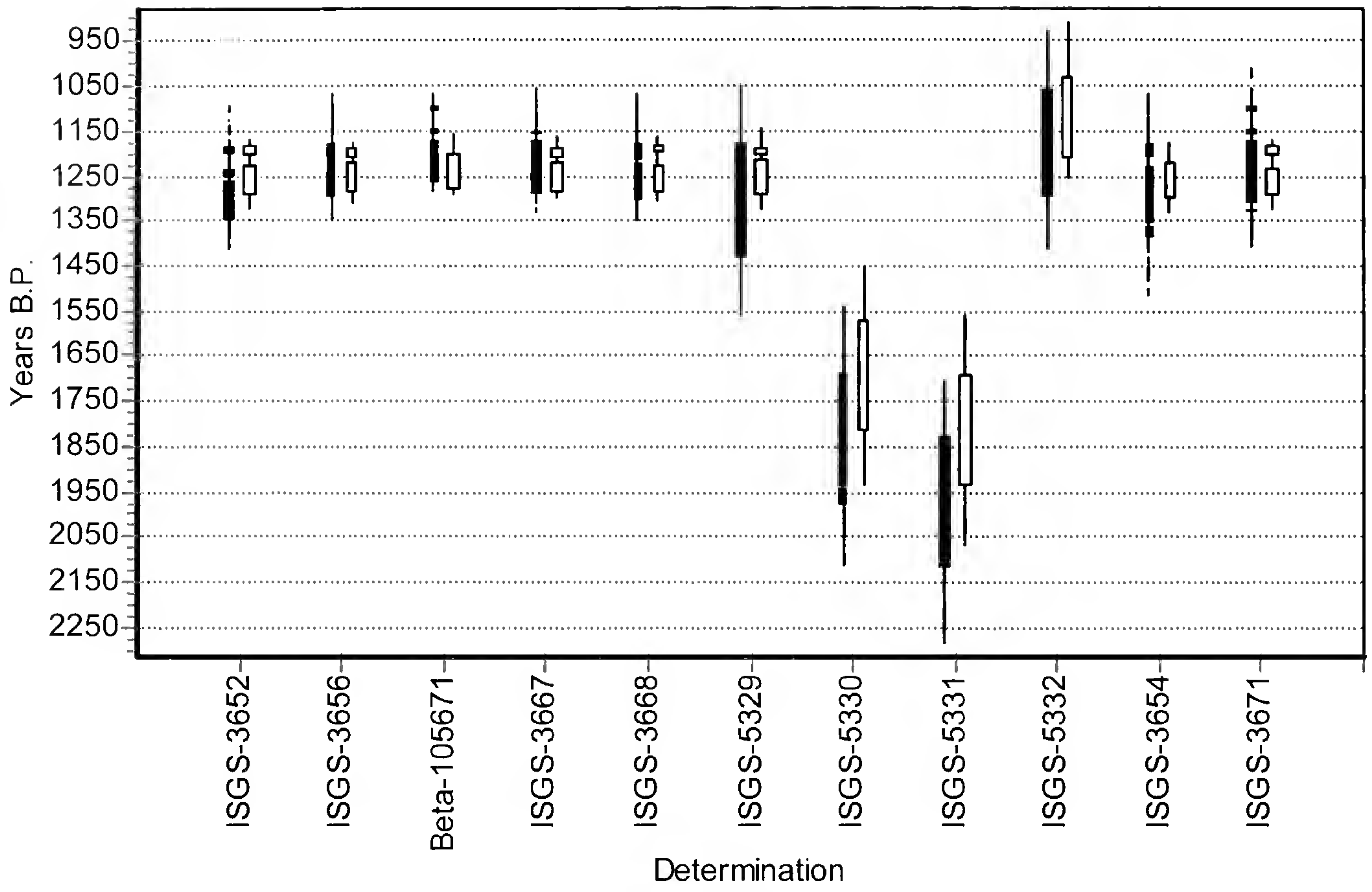

FIG. 14.5. Posterior distributions for θ.

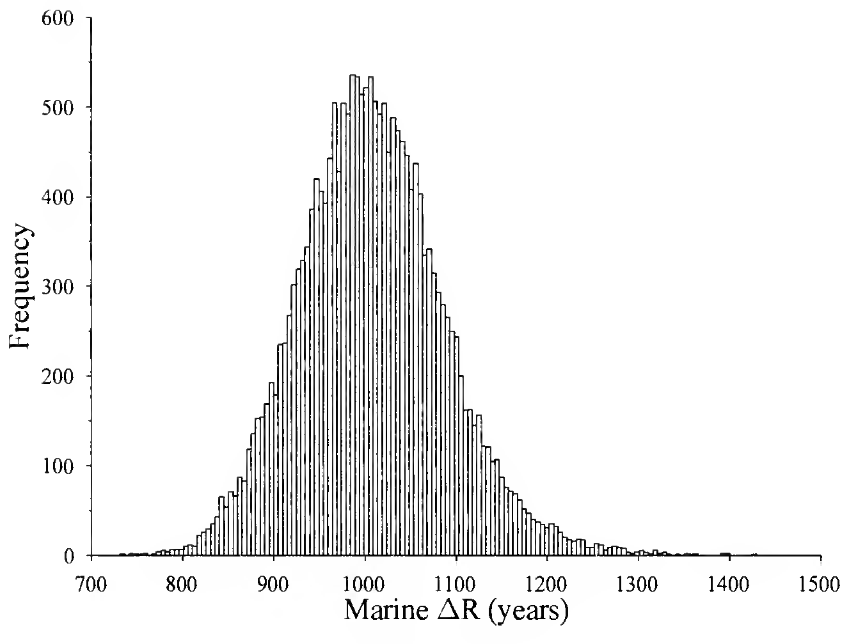

FIG. 14.6. Distribution of a Marine ΔR for the Aitape region.

Summary

This analysis has shown that the dated events associated with the Nyapin pottery tradition fall in the interval 2,000–1,500 BP (95% highest posterior density [HPD]). Because of the limited number of dates, however, it is not possible to draw any precise conclusions regarding the overall chronology of this ware beyond the obvious implication that the cultural tradition was extant sometime in the period 2,000–1,500 BP (95% HPD), and the broad observation that Nyapin Ware began during the period 2,790–1,675 BP. A more precise statement can be made regarding Sumalo Ware. The analysis has shown that Sumalo Ware was being made over a period of between 5 and 270 years (95% HPD) beginning sometime in the interval 1,400–1,200 BP (95% HPD). Additionally, a local marine ΔR of 1,005 ± 80 can be estimated for this location.

TABLE 14.5. Additional shell samples analyzed.[a]

Lab	ID	CRA	Error	Reservoir	Ware	Site	Square	Layer/spit	Location
ISGS	5550	2,110	70	marine[b]	Aiser	NGRP 46	1B	2/1	Tumleo
ISGS	5551	2,180	70	marine[c]	Aiser	NGRP 46	3	2/3	Tumleo

[a] CRA = conventional radiocarbon age before 1950.
[b] *Geloina/Batissa* sp., *Anadara granosa*, *Geloina erosa*, 56.6 gm.
[c] *Batissa* sp., *Anadara granosa*, 49.3 gm.

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Editorial Postscript: Additional Radiocarbon Age Determinations

Additional shell samples from the excavations on Tumleo Island were sent to the Illinois State Geological Survey for radiocarbon age determination after this report was written to further assess the likely antiquity of Aiser Ware. Applying the Marine04.14c calibration dataset (Hughen et al., 2004) leads to the following age estimations for these stratigraphic units associated with Aiser Ware:

ISGS 5550: 2,110 ± 70; Delta R = 1,005 ± 80:
One Sigma Ranges: AD 1199–1392
Two Sigma Ranges: AD 1071–1443

ISGS 5551: 2,180 ± 70; Delta R = 1,005 ± 80
One Sigma Ranges: AD 1114–1312
Two Sigma Ranges: AD 1026–1407

Chapter 15: Conclusions

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Abstract

The investigations described in this monograph have shown us that the Sepik coast is an appealing place where people have devised strikingly effective ways of handling the challenges of living in such a hazardous and changing environment. Contrary to the expectations of some before our fieldwork began on this coast in 1990, we have recovered no evidence linking Lapita pottery in the Bismarck Archipelago directly with early ceramics in mainland Southeast Asia, Taiwan, the Philippines, or Indonesia. Nor have we found anything confirming that the craft of pottery making in northern New Guinea is older than Lapita Ware. However, we have found a range of previously unrecorded prehistoric wares, both locally in the Aitape area and elsewhere along the coast east and west of Aitape. It has been possible to use the ceramic evidence recovered to propose tentative local pottery sequences for both the Aitape and the Serra localities. Additionally, it seems likely that all the ceramic wares, extant and prehistoric, now documented for this coast from Aitape to Jayapura in Papua, Indonesia, are alike derived historically from the same red-slip tradition—which on present evidence was established on Tumleo, for example, around 2,000 years ago if not before. Our sourcing results for both ceramics and obsidian suggest that communities on this coast, as well as those on the nearby offshore islands, have been in contact with people elsewhere in Melanesia at least for the past 2,000 years, and quite possibly for the past 6,000 or more years.

Introduction

In the mid-1980s, Robert L. Welsch and John Terrell began to wonder whether doing fieldwork on the Sepik coast "in the footsteps" of Field Museum Curator A. B. Lewis might be a good way to learn more about the thousands of things made there that Lewis had shipped back to Chicago before World War I. They also wanted to see firsthand if any of the customs and traditions that Lewis had seen and photographed on this coast had somehow managed to survive the passage of time and the devastating impact of World War II on this coast's widely scattered small villages.

Many of their professional colleagues outside the Field Museum of Natural History were quite blunt in telling them that it would be pointless to go to the Sepik coast to explore the prospects for fieldwork there. Surely nothing that Lewis had seen and recorded could possibly have survived all that had happened in northern New Guinea since Lewis's investigations. Here, for example, is what one anonymous reviewer wrote about their first (but unsuccessful) proposal to the U.S. National Science Foundation for research funding:

> The authors are, I suggest, naïve in their expectation that informants [i.e., local people] will be able to provide interesting and reliable comments on photographs of objects collected 80 years ago. Most of the coastal area in question has undergone several generations of intensive acculturation, with a corresponding loss of traditions in the manufacture and use of many of the objects that would be pictured.... The preceding point implies that it would be highly unlikely for the authors to achieve their goal of studying the past and present contexts and meanings of the selected objects—except, perhaps, to say that most of the objects are no longer recognized or used.

When Rob and John were finally able to visit Aitape briefly in 1990 on funding from Walgreen Foundation, Welsch was keen to hire a small boat to take them over as soon as possible to Tumleo Island, one of the several beautiful small coral islands just off the Aitape coast. Lewis had first stepped ashore on Tumleo, locally famous for its handmade pottery, on Thursday, 16 September 1909. They landed at Sapi, a village on the south side of the island facing Aitape a few kilometers away on the New Guinea mainland. This is the beach where Lewis, too, must have landed.

When they climbed out of the outboard boat that had brought them over from the mainland, nobody was around except for a few small children and an older man—who was sitting on a log on the beach painting a small dugout canoe with black paint from a can. Even so, here was someone who looked precisely like the sort of local person they needed to talk to, someone plainly knowledgeable about how people there made things (the canoe seemed a most promising sign!), and someone who also looked old enough that he might perhaps be able to tell them what he had heard from his parents or grandparents about what life on Tumleo had been like back decades ago in Lewis's day.

Rob and John introduced themselves, and soon Rob was sharing cigarettes with this man. He told them his name was Leo Naway. Finally, Rob got around to explaining to him in greater detail why he and John had come over from Aitape. Ever the dutiful assistant, Terrell got out one of their big blue ring binders filled with pictures of objects from Tumleo Island in the Lewis Collection at the Museum that they had brought from Chicago.

Mr. Naway was obviously charmed by these photographs. (Terrell prides himself in being able to read body language, but in this instance, the task was not at all difficult.) Welsch began to probe gently to learn what he might say about the diverse objects shown in the pictures. This was not an easy job. By then, the three of them were literally surrounded by smiling and giggling children, all of whom were trying to get a peek at what the strangers had brought with them.

Naway patiently answered the foreigners' questions, but finally he evidently decided that it was time to respond to their inquiries in a different way. He had just come on their pictures of ceramic cooking pots made on Tumleo many decades earlier. In Lewis's day, women were the potters on the island (as they are still). Mr. Naway may have felt it would be easier to talk about such things to John and Rob if a woman joined their impromptu conversation.

He called out to his daughter-in-law, Helen. When she appeared and had been introduced, he asked her to go into her home and bring out something for the two American visitors to see. She went in and came out with two cooking pots (see cover illustration). These pots had been made on Tumleo by her mother only shortly before the arrival of the foreigners. Both were nearly identical to pots from Tumleo at the Museum (Chapter 8).

Over the next few days in 1990, everywhere John and Rob went on the Sepik coast gave them the same déjà vu experience. When they began showing local people their photographs, people would disappear into their homes. Again and again, they would bring out newly made items to show the two visiting anthropologists. Again and again, local people were able to match what was in the museum pictures item for item. Given more time on the coast, it was plain that anyone could easily put together a contemporary collection nearly identical to Lewis's collection in Chicago, item for item. (Welsch, Terrell, and their New Guinea colleagues from Port Moresby did precisely this during their longer return trips to the Sepik coast in the 1990s.)

To be sure (as recounted in Chapter 4), some of the things still being made on this coast at the end of the 20th century displayed obvious signs of change since Lewis's time (Welsch & Terrell, 1991). For example, people were now commonly using colorful imported nylon twine to make fishing nets rather than locally obtained plant fibers. And while baskets and fish traps were still being made out of native plant materials, women were sometimes adding colorful pieces of plastic and nylon to give them added charm. Similarly, some people now had modern cars and outboard motors, and everybody loved to go over to Aitape to shop when they could. But setting aside such obvious signs of the "outside world," what Welsch and Terrell saw in 1990 was proof that local crafts and traditions were not dead on this coast. What both John and Rob were witnessing was a measure of continuity between the past and the present that was amazing, especially given what their professional (if anonymous) colleagues back home in the United States had been telling them would surely instead be the case.

What Were the Issues We Wanted to Explore?

As discussed in the opening chapters of this monograph, seeing the remarkable persistence of local practices and crafts during the 20th century raised several questions about life on the Sepik coast that inspired the field, museum, and laboratory investigations described in this report. These issues may be brought together as four interconnected themes.

Cultural Survival during the 20th Century—Given over a century of intense contact with foreigners, a world war fought on their doorstep, and many social and economic challenges over the course of the past century, why were local customs and traditions so resilient and enduring?

Linguistic Diversity in the Absence of Social Isolation—Given the wide-ranging character of local community social fields (i.e., the geographic range, or scope, of inherited friendships between families living in different communities on this coast and on the nearby islands; Welsch & Terrell, 1998; Chapter 3), why is the linguistic diversity of this region of New Guinea so extraordinary (Chapter 2)?

Adaptation to a Hazardous and Changing Environment—Given that this shoreline is both where the most favorable habitats for human settlement are located, and yet is also one of the earth's most tectonically and climatically (e.g., El Niño/La Niña events) unstable places to live (Chapter 3), how stable and enduring has settlement been on this coast?

Highway to the Pacific?—Given this coastline's long and seemly exposed position between island Southeast Asia and island places farther out in the Pacific, have settlements on the Sepik coast been "open to receive and transmit cultural influences at all times during the sea-going era" (Golson, 1982, p. 20; Chapter 1)?

Archaeological Correlates and What We Found

Each of these four themes about human settlement and diversity on the Sepik coast has bearing on what life on this coast may have been like in earlier times. While we cannot claim we have resolved these several issues, the findings presented in this monograph, however, relate to all of them.

In What Ways Have Local Customs and Traditions on the Sepik Coast Changed over Time?—We found an impressive range of previously unrecorded prehistoric pottery wares, both locally in the Aitape area and elsewhere along the coastal area surveyed in 1993–1994 (Chapter 5). In the Serra and Aitape localities, it was also possible to use the ceramic evidence recovered to develop tentative local pottery sequences. It seems likely that all the potting industries, extant and prehistoric, on the Sepik coast from Aitape to Jayapura in Papua, Indonesia, described archaeologically for the first time in this monograph are derived historically from the same red-slip tradition, which on present evidence was established on Tumleo, for example, around 2,000 years ago, if not before (Chapter 14).

The diversity of ceramic styles found in the Tandanye-Walifu area suggests that these places just off the coast acquired their pottery vessels from a number of different production centers yet to be located and described archaeologically (Chapter 13). Other than the suspicion that some of the finds at Simindibubu and Sareta on Tandanye stylistically resemble Lapita pottery—and may thus be quite old—it is anyone's guess how the history of these diverse pottery wares encountered east of Aitape should be written.

How Stable and Enduring Has Human Settlement Been on This Coast?—Archaeologists working in coastal southern New Guinea are certain that "the occupation of the south coast by pottery users is considered by all researchers there to represent cultural replacement" (Summerhayes & Allen, 2007, p. 99; see the section **Pottery on the Papuan Coast** below). Unfortunately, too little is presently known about the prehistory of northern New Guinea to attempt to relate what has been learned about the archaeology of the Aitape district to local sequences elsewhere in the north in the manner that Geoffrey Irwin (1991), and more recently, Summerhayes and Allen (2007) have succeeded in doing for the coastal Papuan and Massim areas in the south.

On current evidence, the craft of pottery making reached both of these coasts at more or less at the same time, that is, ~2,000 years ago, if not before. One of the main objectives of the archaeological excavations done in 1996 was to learn whether the history of pottery making in the Aitape area is a story of continuous local production and stylistic development, as we suspected on the basis of our provisional 1993–1994 survey work, or, alternatively, reveals a more complicated story of settlement, conquest or abandonment, resettlement, and the like.

While there is now archaeological evidence of possible human conflict at Aitape in the past (Chapter 10; see also the section Human Remains below)—if we knew for sure what such expressions are intended to convey, words such as "warfare" and "headhunting" come to mind—the Aitape sequence thus far offers no hint of cultural disruption or population replacements (Chapters 2 and 13; see also the section **Interaction and Exchange** below).

Moreover, if the results of the chemical analyses of coastal Sepik ceramics over the past 2,000 years presented in Chapter 13 continue to be supported by future studies, such technologically advanced evidence hints that the survival of pottery making on Tumleo and elsewhere on the Sepik coast into the 21st century is especially noteworthy when seen in the larger context of New Guinea as a whole—for instance, pottery making was eventually lost or abandoned as a craft both on New Britain and in what is now New Ireland Province, following the heyday of Lapita in the Bismarck Archipelago (Summerhayes & Allen, 2007, p. 152). Therefore, the survival of this craft on the Sepik coast may be indirect evidence for the enduring effectiveness of the human adaptive strategies locally practiced, such as the social institutions of inherited friendship and the transgenerational management of natural resources (Terrell, 2006; Chapter 3).

How Isolated Were People Here in the Past?—While a great deal more work must be done in northern New Guinea, it is likely that communities on the Sepik coast not only have been interacting locally with one another for thousands of years, but they have also been tied into the same far-reaching social and exchange networks that had been moving obsidian from places in the Bismarck Archipelago, where it was mined, to other distant places in the southwestern Pacific near and far before, during, and after the popularity of Lapita ceramics in the Pacific (Torrence & Swadling, 2008, pp. 610–611).

Was This Coast a Highway or a Byway in the Past?—Contrary to the expectations of some experts before our work began, we have found no evidence on the Sepik coast linking Lapita pottery in the Bismarck Archipelago (Chapter 5) directly with early ceramics in mainland Southeast Asia, Taiwan, the Philippines, or Indonesia. Nor did we find any evidence confirming that the craft of pottery making in northern New Guinea is older than Lapita (Chapter 5).

However, we now suspect but cannot as yet confirm that Nyapin Ware (as evidenced on Tumleo and Ali islands) and finds at Simindibubu and Sareta not only are similar in age but may alike derive—by pathways as yet uncharted—from the Lapita tradition in the Bismarck Archipelago (Terrell & Schechter, 2007). Given that villages on Tumleo today are Austronesian-speaking communities, and that direct stylistic and semiotic connections can now be proposed between this potter's tradition and the Lapita tradition in the Bismarck Archipelago (Terrell & Schechter, 2007, 2009), it seems likely that pottery making reached Tumleo along with speakers of an Austronesian language. Since nothing is known at present about whether this island was already settled by other people prior to their arrival on the local scene, there is no basis for speculation on how or why potters first came to the Aitape district. There is currently no reason to propose that the art of pottery making reached this coast, as possibly it did in southern New Guinea, during a coastwide migratory "colonization period" (see the section **Interaction and Exchange** below).

Human Remains

In Western societies, we are careful to distinguish between human and nonhuman remains, and treat them differently. In the case of animals killed for human consumption, we also distinguish between flesh and bones. The former is food; the latter is often seen only as waste, or garbage. Except under certain defined and possibly regulated circumstances (e.g., laboratory dissections at medical schools), we make no such distinction when the remains are human. Regardless of their physical appearance or condition, both a human corpse and a human skeleton are to be treated "with dignity and respect."

Fig. 15.1. Daggers made of cassowary tibiotarsus bone; no. 138933, Wanimo, Sepik coast, Sandaun Province, Albert B. Lewis Collection, 1909–13; no. 149007, Angel Island, Sepik coast, Sandaun Province, George A. Dorsey Collection, 1908.

Furthermore, it is normally held to be unacceptable—and, for many, unethical—to recover or retrieve only some parts of a human body (e.g., when a graveyard is being relocated, or at a crime scene), and leave the rest unclaimed, which could lead to the corpse or skeleton being unintentionally (or intentionally) destroyed or misused. It is not surprising, therefore, that when both types of bone, animal and human, are found by archaeologists intermingled in middens and other kinds of deposits, researchers are likely to think they have discovered evidence that the human beings thus attested may have been eaten rather than respectfully treated.

As Stodder and Reith detail in Chapter 10, there is now archaeological as well as ethnographic evidence that people on the Sepik coast in the past did not necessarily distinguish as sharply as many of us would now between human and nonhuman remains. Even bone retrieved by the living after a corpse had become skeletalized might ultimately end up being handled seemingly as midden waste—perhaps, say, after the identity of the deceased either had been forgotten by the living, or no longer mattered to them in some valued way.

While we concur with Stodder and Reith that there is little evidence of butchery and cannibalism in the bioarchaeological evidence recovered during the archaeological excavations in 1996, we are hesitant about agreeing with them that the human bones found at NGRP 16, 23, and 46 had been given (to use their phrasing) "considerate burial" or "culturally sanctioned secondary interment" in keeping with "known patterns of mortuary behavior in New Guinea." Even in the case of Individual 23-6, we wonder instead whether "discarded" rather than "burial" might more effectively describe the treatment that had been given these remains.

With the possible exception of this individual at NGRP 23, we suspect that what Stodder and Reith see as "secondary burials associated with the curation of specific skeletal elements" may not be the only way, other than cannibalism, to explain the human skeletal evidence recovered in 1996. We wonder whether the apparent bundles, or piles, of long bones found at NGRP 16 and 23 might point instead to the local use of human bone not only as ancestral relics or powerful charms, but also as a durable raw material suitable for making tools and weapons. It is known ethnographically, for instance, that human long bones and the tibiotarsal bones of cassowaries were alike used in northern New Guinea for fashioning ornately decorated bone daggers (Newton, 1989)—the Museum's ethnographic collections from this coast amply attest to the skillfulness of this form of local artistry (Fig. 15.1).

Interaction and Exchange

The arrival of pottery making in southern New Guinea about 2,000 years ago has long been seen by archaeologists as swift and sudden in its timing and determined in its course—the manifestation of a coastal migration by Austronesian-speaking, canoe-building people who quickly settled down in coastal places such as those now called Oposisi, Nebira, and Mailu. Additionally, based on certain stylistic similarities, the pottery these migrants made is generally thought to be derived historically from the Lapita ceramic tradition, although a direct connection with Lapita has so far not been adequately demonstrated (Bulmer, 1999, pp. 571, 573–574). It is instructive, therefore, to compare what has been written about the history of pottery making in southern New Guinea with what we have now learned about the history of this craft on the Sepik coast.

Pottery on the Papuan Coast

Summerhayes and Allen say that early pottery making along the south coast went through an initial "experimental" phase during which potters tried out local clays and tempers in various combinations perhaps to see, among other things, what worked and what did not. Once suitable clay sources had been found locally, however, potters evidently ceased being so adventurous (Summerhayes & Allen, 2007, p. 115). This shift in potting strategy—which mirrors, they say, a similar change seen also in the Lapita ceramic tradition—is believed to reflect a change in settlement mobility, too. The more experimental tactic used initially is a clue, they suggest, that there was greater human mobility during the colonization period. They see the later, less adventurous (or, in their phrasing, the more "conservative") approach to pottery making as a sign that people were becoming more fixed and sedentary in their ways (Summerhayes & Allen, 2007, pp. 109, 114–115).

Also according to Summerhayes and Allen (2007, p. 100), archaeologists working in southern New Guinea believe there was a break, or disruption, of some kind between 800 and 1,200 years ago witnessed in all the ceramic traditions that grew up locally following this initial experimental phase of pottery making. In Irwin's (1991, p. 507) estimation, there was "a widespread transformation expressed everywhere in local terms insofar as all of the replacement pottery industries were different from one another as well as from what preceded them." Consequently, the history of pottery making in southern New Guinea can be subdivided "into a more recent phase, where pots although prehistoric, have generic associations with local ethnographic wares, and an earlier phase where different generic relationships were observed archaeologically between regions" (Summerhayes & Allen, 2007, p. 100). Furthermore, more may have been involved than pottery making. There apparently were also "socio-economic system changes along the entire coast" (Summerhayes & Allen, 2007, p. 100).

Whatever these changes were, it seems that potters on the south coast after AD 1200 were producing pottery in new styles (Irwin, 1991, pp. 506–507). In addition, as Geoff Irwin documented years ago using an approach to the chemical analysis of pottery and clays similar to that reported in Chapter 13, how pottery was made and marketed in the Mailu area of southeastern Papua also evolved over time. Mailu potters gained increasing manufacturing dominance after AD 1200–1400; they had achieved local monopoly in the production of pots by ~AD 1885–1890 (Irwin, 1978, pp. 314–315).

A Different Story

Our stylistic (Chapter 7) and chemical (Chapter 13) results have documented a seemingly continuous, unbroken tradition of pottery making at Aitape spanning the past 1,500–2,000 years. The evident lack of obvious full-blown Lapita sites on New Guinea has led some archaeologists to propose that "the New Guinea mainland was avoided by Lapita makers and users" (Lilley, 2008, p. 79). Yet not having solid evidence for direct Lapita pottery production on New Guinea does not have to mean the Sepik coast was cut off for some unknown reason from the rest of Melanesia during the time of Lapita's production and use elsewhere. It is now certain that Lapita pottery was either imported to the Aitape area at least in small amounts, or made there occasionally (Chapter 13). Regardless of whether Lapita pots were being locally produced, stylistic influences of Lapita-derived motifs can still be seen on this coast in other classes of material culture (Terrell & Schechter, 2007, pp. 81–82; Chapter 9).

Pottery alone, however, cannot be used to tell the story of coastal Sepik prehistory. The importance of the Talasea locality on New Britain as a source of obsidian in the second and first millennia BC is witnessed on this coast by the surface collections made in 1993 and 1996 at Kobom on the mainland and on Ali Island. Both locations have higher recorded frequencies of Talasea obsidian than any of the other localities surveyed. As discussed in Chapter 13, we suspect that settlement on Ali may be at least as old as early Lapita in the Bismarck Archipelago (i.e., people were probably settled there ~3,000 or more years ago), and settlement at Kobom may be a lot older (perhaps as old as ~6,000 years or more). If these suppositions are shown to be correct by future archaeological work at Aitape, then these site localities directly challenge Tiesler's hypothesis that ancient communities on this coast were strongly isolated from one another as well as from more distant places elsewhere in Irwin's voyaging corridor (Irwin, 1992) prior to the arrival of Austronesian speakers on this coast.

By the time Nyapin Ware was being made on Tumleo (and different but possibly contemporary wares were being obtained by people on Tandanye from as-yet-unidentified pottery-making communities), obsidian from distant Talasea on New Britain was reaching the Sepik coast only in small amounts (assuming that the rare pieces of Talasea obsidian excavated on Tumleo are not derived from older contexts). By then, geographically closer sources in the Admiralty group were dominant instead (Chapter 13). Over the course of the next 1,500–2,000 years, there is no sign that the availability of obsidian coming from either New Britain or the Admiralty Islands at any time changed significantly. Importantly, there is no suggestion in the information currently available that there was a hiatus in the availability of obsidian at any time comparable to that reconstructed at archaeological sites in southern New Guinea (Irwin, 1991, pp. 504, 506).

The evidence from Aitape and localities in the Serra Hills, as well as from offshore islands in the Wewak area, suggests that the Sepik coast has also differed from the Papuan coast in the patterning of ceramic production, exchange, and gifting over time. Tumleo Island is in many respects geographically analogous to the small islands of Yule and Mailu off the south coast. Like Tumleo, these other islands have long-established ceramic traditions, and like Tumleo, do not raise enough food locally to feed all the people living on them. Hence people on these islands, too, have long been exchanging pots for food with communities on the mainland (Irwin, 1991, p. 509). Yet unlike people on Mailu or Yule, potters on Tumleo—judging by the evidence discussed in Chapters 5 and 13—apparently never gained a monopoly over coastal pottery production (Welsch & Terrell, 1998). There were communities on the adjacent Sepik mainland apparently making Sumalo Ware pots during the second half of the first millennium AD, and it is currently anyone's guess whether the same was true for Nyapin Ware. Furthermore, later Tumleo-made Aiser and Wain wares have thus far been found only rarely and in small quantities at mainland archaeological sites beyond the immediate Aitape district. Far from Tumleo eventually gaining a monopoly over the production of pots on the Sepik coast, there were a number of established potting communities inland and along the coastline west of Aitape in Lewis's day—although most of these communities did stop making pots at one time or another during the past century, leaving only Tumleo today with a vigorous industry.

Summing Up

These complementary lines of evidence (analytical, archaeological, and ethnographic) all seem to point to the same likely conclusion. Pottery making at Aitape has been a continuous tradition ever since this craft was brought to this region of New Guinea. Furthermore, in light of the evidence presented in Chapter 13, pottery making on Tumleo has also been a strikingly conservative and standardized industry since its original introduction. This discovery is all the more remarkable given that the elaborate mixing of ingredients involved in the production of Tumleo pots today (Chapter 8) is not simple and straightforward. In the words of May and Tuckson (1982, p. 310), the "preparation of the clay here is a far more elaborate process than anywhere else in Papua New Guinea and even includes the use of a specially made cane sieve, unique in the country." Yet, remarkably, the same potting ingredients and blending recipes have evidently been in use on Tumleo for hundreds, maybe even thousands, of years.

In contrast, a great deal is yet be learned about the history of pottery making on the mainland at Aitape and elsewhere on the coast. However, the sourcing of Sumalo Ware sherds to Serra Hills clay sources (Chapter 13) suggests that the art of pottery making may have been established on the mainland as early as ~1,400 years ago. Far too little is presently known about the prehistory of ceramics in the Serra and Leitre areas, but it seems likely that the craft of pottery making was well established in both of these locales by the time Wain Ware was in production at Aitape. Unlike Wain Ware, however, pots made then in both of these two other areas on the coast were still being decorated before firing with a clay slip, an ancestral ceramic trait abandoned at Aitape when Wain Ware became locally popular.

Other Historical Implications

Pamela Swadling (1997), Jim Roscoe (1989), and others have argued that major population displacements and relocations—human migrations in a more restricted sense than commonly implied in more encompassing reconstructions of Pacific prehistory—have dynamically framed the history of human settlement in the Sepik River region of northern New Guinea. Nothing that we have been able to piece together so far about life on the Sepik coast during the past 2,000 years, however, hints that major population displacements and relocations have been as influential on the Sepik coast, which is not to say that people have not been moving around locally from place to place for a variety of reasons.

In this regard, the linguists Mark Donohue and Melissa Crowther (2005) have documented for this part of New Guinea how linguistic features have evidently diffused between local speech communities much more rapidly in their estimation than often assumed in models of language contact. They report that language evidence as well as local oral histories alike show how common it has been for people here to move around from place to place in relatively short order. However, in their historical reconstructions, they assume that contact between speakers of Austronesian and non-Austronesian languages on the Sepik coast has been only recent and relatively limited, suppositions that fit poorly with the archaeological evidence discussed in this monograph.

Significantly, our sourcing results for obsidian and ceramics show that communities on this coast and on the nearby offshore islands have been in contact with—and hence have been open to being influenced by—people living elsewhere in Melanesia at least for the past 2,000 years, and possibly for as long as the past 6,000 or more years. What we think currently stands out is the evident stability of Aitape's ties with people elsewhere in the southwestern Pacific over the course of many millennia. Therefore, the hypothesis is worth exploring that this social (and evident demographic) stability has nurtured—that is, enabled—the growth of local language diversity on this coast despite the fact that people in the Aitape area have been not only aware of people living elsewhere on New Guinea and in the Pacific, but also actively engaged with others elsewhere near and far in various ways for untold years.

Social Complexity and the "Sepik Paradox"

Many theorists of social change (e.g., Carneiro, 2002, p. 35; Marcus, 2008, pp. 255–256) have written about non-Western societies as if they were in effect social realms where every local community is more or less autonomous and set apart from others in its dealings with the world. In our estimation, such thinking is just another facet, or expression, of the familiar and long-established "myth of the primitive isolate" so prominent in Western philosophy and social, political, and economic theory (Chapter 1). We think it is revealing that ethnographers writing about Melanesian communities are instead far more likely, as Jim Roscoe (1996, pp. 646–647) has observed, to describe the pace and patterning of daily life quite differently. For Pacific experts, the lives of both individuals and whole communities are richly embedded in far-reaching social, economic, and political webs of relationships, obligation, friendship, and sometimes patterned hostility.

A week-long Wenner-Gren Foundation conference held in Mijas, Spain, in 1986 attended by 20 leading Sepik scholars sought to pull together what was then known about the remarkable cultural diversity of the Sepik region (Lutkehaus & Roscoe, 1987; Lutkehaus et al., 1990). While the focus of this gathering was largely on communities in the Sepik River basin, it soon became evident that the sociopolitical heterogeneity of this entire region of New Guinea is striking. Societies organized around ideologies of rank and ascribed office have neighbors who display all the classic traits of big-man polities, big-man polities vie with others featuring classic elements of ascribed leadership and social stratification, and so on.

The participants in 1986 talked at length, however, about what has been dubbed "the Sepik paradox": despite their obvious heterogeneity, Sepik societies also display striking regional, or areal, commonalities. It was suggested at the conference that the key to this paradox may be the extraordinary intensity of what Margaret Mead (1938, p. 162) characterized as "the purposive diffusion, sale, and exchange of ceremonial paraphernalia, magical charms, methods of divining, new forms of social organization, etc." Thus, in the estimation of at least some at the conference, local identities in this part of the world are constructed through the artful and self-conscious selection of "signature" elements from a broadly known and widely available regional pool of cultural traits, practices, beliefs, and the like—a process of identity formation that Simon Harrison collectively referred to during the conference as "a cobbling together" of individualized cultures. As later summarized in *Current Anthropology* by Nancy Lutkehaus and Paul Roscoe (1987, 579–580):

> The singular spatiotemporal node that each community occupies in the flow of Sepik intercultural traffic produces a unique constellation of cultural traits that generates local diversity. But, at the same time, this process is responsible for a general diffusion of cultural themes which, from a regional perspective, serve to create cultural unity within the Sepik area as a whole.

Therefore, while unmediated by centralized political or economic institutions before the arrival of European colonial powers and more recent national developments during the past century—hallmarks of societies conventionally labeled in current anthropological theory as "complex" rather than "simple"—there is little doubt that people in the Sepik region have long been anything but "isolated" and "autonomous" in their dealings with the world and with their neighbors near and far.

Furthermore, as Roscoe (2000, p. 96) has noted, archaeologists need to be able to explain why societies like these in northern New Guinea have been able to succeed so effectively while relying on only "egalitarian" rather than "complex" forms of regional integration. In this regard, we think the findings presented in this monograph bearing on the transport of obsidian and pottery between communities add a much-needed dimension of time to the "Sepik paradox." In our estimation, the Sepik coast thus serves as a cautionary tale that when human interactions and social networks in "noncomplex" societies are studied in depth—and their components are fully unpacked—"complexity" as commonly understood by archaeologists for the most part refers to hereditary social stratification and urbanism, and little else.

Where Further Investigations Are Needed

In our estimation, there are four principal areas where additional research is critically needed.

Documenting Source Materials

The provenience work we have done on the Sepik coast, as well as that done by others in southern New Guinea, shows how important it is to collect clay and temper materials while doing fieldwork. For example, in his provenience studies in the Mailu area, Irwin was able to match particular clays to different pottery chemical groups (Irwin, 1978, pp. 312–314), as was the case also in the chemical analysis reported in Chapter 13. In contrast, Simon Bickler's efforts to distinguish between pottery from Yule Island and from sites in the Port Moresby area were hampered by a lack of information on source materials—which made it difficult for him to estimate the degree of variation relevant for distinguishing clay and temper sources (Bickler, 1999, p. 472).

This limitation also somewhat hampered our own investigations on the Sepik coast, as clay samples were available only from known sources in the Serra Hills and in the immediate Aitape area. However, the samples we were able to collect in both locales proved invaluable, especially in conjunction with ethnographic information on local pottery making in the 20th century. For instance, being able to compare archaeological finds with historic and modern Tumleo pots, as well as with samples of prepared and unprepared clays used by modern Tumleo potters, gave insights into local pottery making that might otherwise have been unachievable.

Additional intensive clay survey work on this coast, assisted where possible by local potters, should lead to clearer geographical understanding of the chemical signatures of available and prehistorically exploited potting materials. Moreover, there are many places on the coast, as well as in the nearby hinterlands, that were not explored as part of the field investigations reported here. Collecting and analyzing modern pottery and raw materials from these localities may help pin down where the currently unassigned ceramic specimens from Tandanye and Walifu, for instance, were made. Furthermore, similar analytical work elsewhere in Melanesia—chemically assaying Lapita ceramics from sites in the Bismarck Archipelago, for instance—may help pin down the source of the Tubungbale Lapita sherd.

Improving the Resolution of the Aitape Ceramic Sequence

Our current understanding of Nyapin Ware is limited to one test pit on Tumleo and a few sherds from Ali Island. Furthermore, while the stylistic characteristics of Wain Ware are now reasonably well understood, the antiquity and chronological span of this distinctive ware remain undocumented. While it is likely that Sumalo and Aiser ware pots were made not only on Tumleo but also on the Aitape mainland, the locations of these mainland production centers are unknown.

Prehistoric Settlement and Land Use

Archaeological and geomorphological research is needed to explore and evaluate our five working propositions about the growth of this coastline as a natural and human environment. Specifically, we have hypothesized the following:

1. During the late Pleistocene and early Holocene, there were few stable, productive lowland areas on this coast suitable for human use.
2. Since the mid-Holocene, coastal lagoon, swamp, and forest ecosystems have developed or expanded, providing new opportunities for human settlement.
3. In the late Holocene, continued progradation of this coastline has caused many of the mid-Holocene lagoons

to silt in, focusing human settlement around those remaining (e.g., the lagoons at Sissano and Malol).
4. Earthquake-induced tsunamis have repeatedly impacted this coast, yet this shoreline has nonetheless remained a focus of human settlement.
5. People on this coast are fully aware of the dangers of living there, and have devised and continue to follow transgenerational resource management practices to maximize their subsistence success and buffer their environmental risks over long intervals (e.g., decades and centuries rather than weeks, months, or years).

Transgenerational Management of Resources

Work with local landowners is needed to document their resource management practices, map coastal habitats favorable to human settlement and subsistence during the past 6,000 years, and document prehistoric resource management practices archaeologically to establish long-term patterns of continuity and change in resource species use and subsistence practices.

In the Footsteps of A. B. Lewis

How life is lived on the Sepik coast is little known even to people elsewhere in New Guinea. Our field investigations there have shown us an exceptionally appealing place where people have devised remarkable ways of dealing with the challenges of living in such a hazardous and changing environment. As a case in point, the first day that Rob Welsch and John Terrell visited Tumleo in 1990, Terrell pointed out an outrigger canoe on the beach at Sapi that looked incredibly like a canoe pictured in one of the old Lewis photographs from 1909. "But you know what's missing here, don't you?" John said to Rob. "This canoe doesn't have a bundle of sago on it." In Lewis's photo, somebody had placed a large bag of this favorite local food on the canoe he had immortalized in grainy black and white.

After touring the island, Rob and John returned in the late afternoon to the same beach at Sapi. The canoe in question was still there. But during their absence, someone had contributed a new element to the picturesque beach scene. A large bundle of sago had been left there, although this time around it—unlike back in 1909—the bundle had simply been set down next to the canoe, not actually on it. The sense of déjà vu was particularly remarkable since this particular photograph was *not* among those Lewis had taken that they had brought with them to show people locally in 1990. Terrell at once quipped to Welsch: "*Now* I know why we had to come here. Lewis didn't have color film. But we do!"

On another day and at another village—this time on the New Guinea mainland—they were walking down the beach together alone. Far off ahead of them were two young boys. John noticed that the boys were leaving small footprints in the sand. He turned to Welsch and said: "You know, Rob, we have a problem."

"What?" Rob asked.
"Well, you know we call our project "In the Footsteps of A. B. Lewis."
"Yes, what of it?"
"Well, look at that."
"Yes?"
"The problem is, well, we don't know Lewis' shoe size."

These stories are only anecdotes; they are not scholarly arguments. They show, however, how astonished—as well as how delighted—both Welsch and Terrell were in 1990 to find that customs and traditions were so alive and well on the Sepik coast. Yes, it was great to feel that they had not been fools to want to come to New Guinea in the footsteps of A. B. Lewis. But on a deeper level, both were moved by the human strength of what they were witnessing. Who knows what the future will bring. But what they were seeing then said to them that the diversity of what it means to be human is not a fragile accident of history or isolation. It is conventional wisdom to claim that change is inevitable. So, too, it seems is human variation and the value of traditions—even in the face of colonialism, a world war, and what the world now sees as modernization.

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