

Hafted stone tools in the Asia Pacific region

Author's note: this draft is intended as a background chapter for a book on the material culture of Papua, provisionally titled 'Stone and Fiber: the Hampton Archive of the Material Culture of the Baliem Valley', slated for publication in 2023.

Comments on this draft are welcome: please contact me at chrisbuckley888@hotmail.com or via Twitter.

Chris Buckley, 11th October 2022

Abstract

Hafted stone tools fell into disuse in the Pacific region in the 19th and 20th centuries. Before this occurred, examples of tools were collected by early travelers, explorers and tourists, which now reside in ethnographic collections around the world. Together, these objects make up a remarkable record of vanished traditions. In this chapter I assemble the most extensive survey of these tools to date. I discuss their distributions and how these relate to lifeways and cultural histories. In highland New Guinea I show how hafted stone tool forms trace three waves of agricultural innovation. I also show how convergent evolution has shaped similar tool types in the Asia Pacific region and the European Neolithic.

Hafted stone tools in the Asia Pacific region

1. Introduction

When I began writing this chapter the aim was to provide context for the ethnographic stone tools of the Baliem Valley, in the eastern highland region of New Guinea, that are one of the subjects of this book (Chapter xx). While there is a great deal of literature on stone tools from New Guinea and surrounding regions, much of this is in the form of books and papers that deal with localized areas and topics. As I worked through a small mountain of material on ethnography and archaeology it became clear that interesting patterns are present over a variety of scales, and a survey that covered a wider area in the Pacific region could be a useful exercise.

Across the globe, the study of stone tools has mainly been a subject for archaeologists. Most readers will probably know that during the 20th century stone tools were still in use by isolated peoples in the interior of New Guinea and Australia. Less well-known is the fact that examples of stone tools that were still in use (or had recently fallen into disuse) were collected from the entire Pacific region by western visitors during the 19th century and the early part of the 20th century. These ranged from casual purchases by tourists to systematic collecting expeditions such as that conducted by A. B. Lewis on behalf of the Field Museum in Chicago. This record of ethnographic hafted tools across the vast Asia Pacific (AP) region is a unique and under-utilized resource. Stone tools were made and used across the region from the time of its earliest settlement, and there was continuity between archaeological, historical, and ethnographic evidence of stone tool use, as well as the peoples who used them. At the time that western traders, colonists and tourists entered the Asia-Pacific region, stone tools were already in decline, subject to slow replacement by locally-made iron blades that had been spreading gradually eastwards for two millennia, carried by traders. This decline was greatly accelerated by trade with Europe and the importation of iron tools.

The most important compendium of information for the ethnographic tools of the near-Pacific is the PhD thesis written by Eleanor Crosby (1973). Crosby surveyed a large number of hafted stone tools from Melanesia and Micronesia, mainly in antipodean collections. At the conclusion of her study, she distilled the hafting styles in Melanesia and Micronesia into four 'traditions' (T1 to T4). She represented these on a sketch map of the region, which is most clearly reproduced in Axel Steensberg's book (1980: 22). Crosby's map is useful, but it does not do justice to the wealth of detail that she uncovered. As I will show, re-plotting Crosby's tools, adding more subdivisions to the groupings she identified, and expanding the geographical range reveals a great many interesting patterns.

I began by putting Crosby's data (about 150 datapoints) on a new map.¹ Since Crosby's research did not include many tools from Australia, and none from ISEA or Polynesia I added around 100

¹ I used the data for individual tool types, set out in the Appendix to Crosby's thesis (1973b). This involved some challenges since the names of many places (particularly in New Guinea) have changed since colonial times, and the

new examples from these regions. The complete map and raw data can be viewed online at this link:

https://www.google.com/maps/d/edit?mid=1D_sC7VUtQRuRcCgc9rROVU7ghrdiVAg&usp=sharing

The new examples that I added are contained in an excel spreadsheet in the Supplementary Material.

The challenges with a review covering a lot of information over a large area are distillation and presentation. It is asking too much of readers to visualize the geography of the Pacific with its innumerable islands and at the same time to recall the appearances of different kinds of stone tools based on text descriptions. I have therefore chosen to build this review around maps and drawings that illustrate both types and locations. My inspirations were twofold: firstly C. C. F. M. Le Roux's map of New Guinea (1948-50) showing stone tool types, which is a masterpiece of clarity,² and secondly the detailed maps of stone tool types in Indonesian Papua (Irian Jaya) by Anne-Marie and Pierre Petrequin (1993, 2020).

The bulk of what I will share here is built on the work of these and numerous other authors, mentioned in the text. In keeping with the subject of this book, I devote closest attention to the New Guinea highlands. In this region I 'join the dots' to create a model for the spread of tools, farming and languages. I suggest that the highland landscape bears the imprint three distinct waves of innovation in stone tools, linked to the emergence and intensification of agriculture.

The Asia-Pacific region

The region that will be considered, with its conventional subdivisions, is shown in Fig 1. These divisions have cultural relevance, but it should be kept in mind that their boundaries are to some degree arbitrary. The dividing line between Melanesia and Polynesia, for example, is a gradation: Fiji is usually included in Melanesia but has much in common culturally with Polynesia.

Objectives

The focus of this study is hafted axes and adzes made of ground and polished stone and shell, as they existed in the Asia Pacific in the recent past, mostly collected from about 1880 to about 1980. Axes and adzes were used for cutting and shaping vegetation, particularly wood. Their uses extend into other realms however, including warfare, wealth, trade, and status.

My objectives are to answer the following questions:

1. What kinds of hafted tools existed in Asia Pacific, and how were these types distributed?
2. What factors can explain these distributions?
3. What can we learn by comparing Asia Pacific hafted tools to those of other regions?

spellings of other names are inconsistent. I was able to identify sufficient to assign Crosby's tool types to about 150 distinct locations.

² This map is also reproduced in Axel Steensberg's *New Guinea Gardens*, Figure 18.

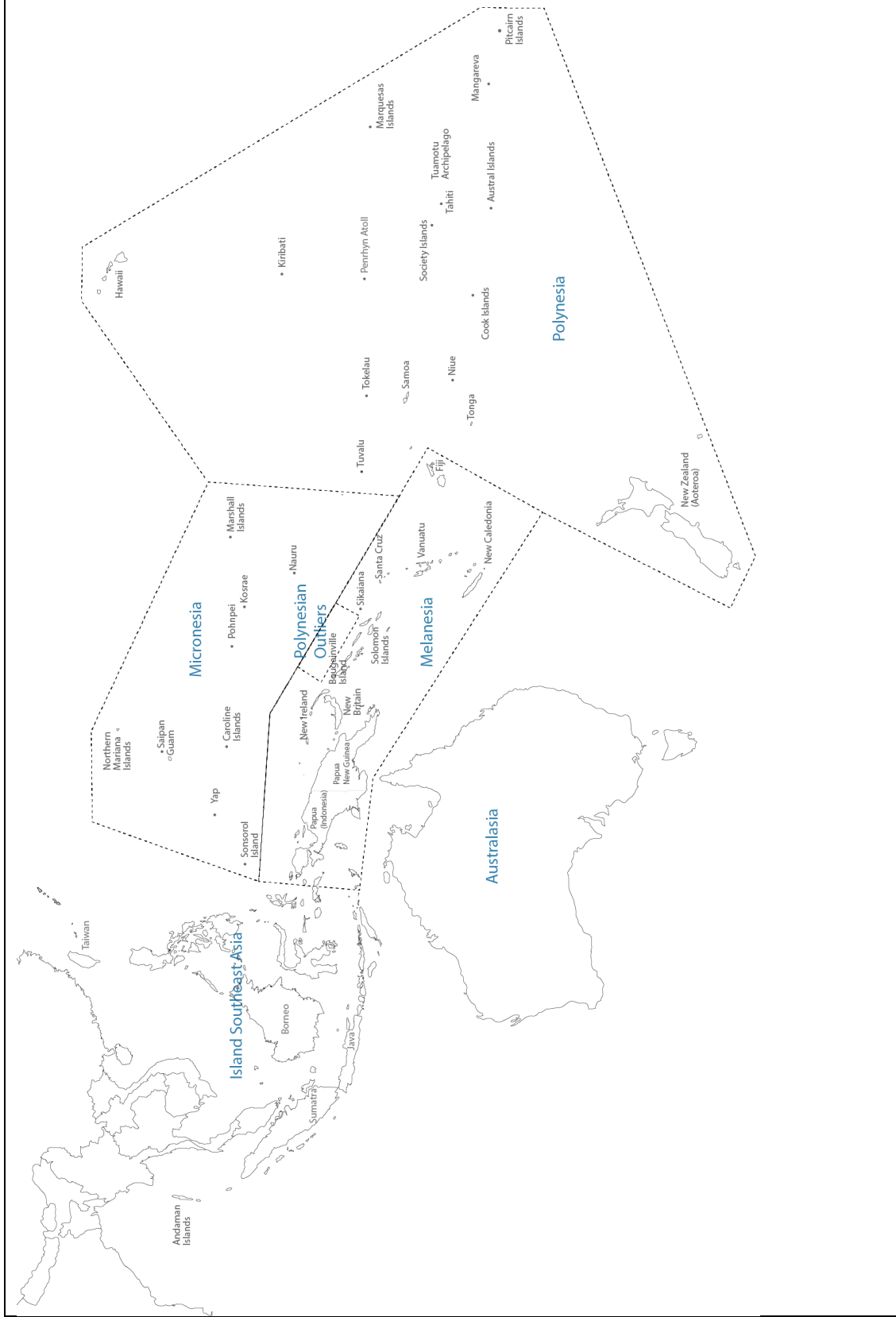


Fig 1. The Asia-Pacific region and sub-regions.

Ethnography versus ethnoarchaeology

As stated in the Introduction to this book, this is an ethnographic study, the primary aim of which is to shed light on tool use in the AP region. In contrast to this, much recent work done on stone tools in New Guinea follows an 'ethnoarchaeological' approach, which takes as its objective the understanding of archaeological data. As Petrequin and Petrequin wrote: 'We see our study of the ground stone blades of Irian Jaya not so much as an end in itself but rather as the key element of a renewed approach to the ground stone blades of the Western European Neolithic' (2020:256). Similarly, Hampton's view of his work in the Baliem Valley was that his mission was 'primarily to assist archaeologists' (1999: xvii).

I have no objection to pursuing ethnoarchaeological objectives, but in this survey my primary focus is the AP region so I will formulate no 'ethnoarchaeological models'. Comparisons that I make between regions, a topic I will return to near the end of this chapter, will also be more compelling (I think) if the interpretations have been arrived at using independent data and reasoning.

The significance of edge grinding and hafting

The earliest stone cutting edges were made by fracturing the raw material, as opposed to grinding it. Tools were shattered or flaked into suitable shapes, and most of these tools were held directly in the hand when they were used. Producing and maintaining a precisely shaped cutting edge required expertise in selecting and flaking stone. Once dulled, such an edge needed attention from an expert to restore it.

In contrast to this approach, a hafted tool with a ground edge embodies two innovations: the additional leverage and reduced shock on the hand and wrist afforded by a haft, and the possibility of resharpening by anyone (including non-experts) in possession of a grinding stone.

Though most contemporary cutting tools are made of steel, edge-grinding using gritstones (natural and artificial) is still the way that nearly all sharp edges are generated and maintained. Most such implements, whether in the kitchen or workshop, also incorporate a handle. In this sense ground-and-hafted blade technology remains a basic part of the human tool repertoire.³

The independent emergence of edge-ground tools in multiple locations

Remarkably, the earliest evidence of edge grinding on stone tools anywhere in the world has been found at Carpenter's Gap in Australia, where fragments of edge ground stone tools were discovered dating to between 49 and 44kya (Hiscock et al 2016). There is no evidence that this technology was introduced, it seems to have been invented locally. Evidence for the use of grindstones is even older, dating back to around 65kya at Madjedbebe in northern Australia (Hayes et al 2022).

³ Despite the ascendancy of grinding techniques, the sharpest man-made edges, such as those used as microtome blades for electron microscopy, are still made by fracture (breaking glass bars). The same approach has been used in Pacific Islands for at least 39,000 years to make cutting edges from obsidian (natural volcanic glass).

Aside from the occurrences of ground tools in Australia, fully ground and partly ground axes have been found in sites dating between 38 and 32kya in central Japan (Honshu), as described by Oda and Keally (1992), and Takashi (2011). Some of the Japan tools have the classic trapezoidal axe shapes and are ground over a substantial portion of their surfaces, with a prominent bevel at the cutting edge. Use-wear and damage on these axes suggests that they were heavy-duty tools used for cutting down trees and woodworking, implying that the axe heads must have been hafted onto sturdy handles. Interestingly, these tools pre-date the appearance of agriculture in Japan.

Edge-grinding appeared on the Asian mainland significantly later, at around 20kya. A typical sequence is that at the Bailiandong cave in Guangxi Province, described by Zhou et al (2019). The oldest fully-ground and polished tools are classic lenticular-section stone blades that began to appear around 10kya (Zhao et al 2004).

In China and most other parts of the world the appearance of fully ground stone tools was associated with the emergence of agriculture, along with sedentary lifestyles that permitted the production and accumulation of valuable tools. In the Levant they appeared around the time of the PPNA-PPNB transition (Bar-Yosef 1998, Yerkes et al 2012), also around 10kya. In northern Europe ground blades appeared during the transition from the Mesolithic to the Neolithic, around 9500ya, some of the earliest examples being found in Ireland (Woodman 1977). In sub-Saharan Africa, ground stone axes appeared sporadically between 8000 and 7000ya (Posnansky 1981).

In contrast to flaked stone tools, which are often taken as indicators of migration, there is little or no correlation between the first appearances of ground-edge stone tools and patterns of human migration. In the majority of cases there are links to the emergence of agricultural lifeways, though the early examples in Australia and Japan show that this was not invariably the case.

2. Typologies

The first typology of ground and polished blades in the AP region (that I am aware of) is the one set out by Robert von Heine-Geldern (1932), who distinguished three types:

Walzenbeil: blades with a lenticular cross-section and a teardrop-shaped outline, presumed to be the oldest type

Verkantbeil: the 'four cornered adze' or quadrangular adze, with a rectangular or trapezoidal outline

Schulterbeil: 'shouldered adze', a development of the Verkantbeil with shoulders and/or a distinct tang to aid hafting.

This basic three-fold division provided the foundation for Roger Duff's more elaborate typology of adze blades (Duff 1970). This describes and classifies the many and varied blade forms that appeared across the offshore AP region from around 5kya onwards. These sophisticated ground tools were mainly, but not exclusively, associated with migrations of Austronesian-language speaking peoples. Duff's typology was recently reexamined by Shipton and colleagues (2016),

who assessed his categories using a morphometric study and principal component analysis. They found ambiguities in the finer subdivisions of Duff's scheme, but his broad categories were recoverable by this quantitative method, and his scheme continues to be a useful descriptive tool.⁴

Since I will focus on hafting, for the purpose of this review it will be sufficient to distinguish five categories of blade: lenticular, quadrangular and shouldered blades (in essence, Heine-Geldern's original three categories), plus planilateral blades and waisted types. In practice, applying blade typologies to ground tools is difficult: we are dealing with continuous variables, and blade shapes change continuously during their lives as they are re-sharpened.

Typologies of hafted forms

To describe the forms and distributions of hafted tools, I will use a typology that is based, in the first instance, on hafting method. This is a much more straightforward problem than building a typology based on blade shapes, since we are mostly dealing with discrete rather than continuous variables.

A typology is a tool: a useful one should (ideally) reflect both the forms and the functions of a group of artifacts and should encompass the known types. Authors create and/or modify typologies in order to highlight features and distributions that they think are important, and this survey will be no exception. Several typologies of hafted tools have been generated by previous authors, some of which are summarized in Table 1. The most relevant of these for this study is the one due to Crosby (1973, 1977). The classification I will use here is similar to Crosby's but differentiates key hafting types more explicitly. Like Crosby's system it is based on blade-to-haft attachment.

⁴ In recent years archaeologists have created quantitative schemes for classifying stone blades, based on morphometric analysis (measuring the surface topology of blades, particularly key measures related to dimensions and angles of blades), such as Shipton and colleague's analysis mentioned above. These approaches have been successful for analyzing certain datasets, but no all-embracing scheme for characterizing and classifying stone tools has so far emerged from this work. Qualitative, descriptive typologies continue to be the first line of approach.

Table 1: comparison of hafted tool typologies

This work	Description	Leroi-Gourhan 1971	Crosby 1977	Suter 1981*	Stockli et al 1995
F-axes	Folded handle wrapped around blade	-	T3	-	-
M-axes	Blade fixed mortise-and-tenon fashion	4	T3	-	1
T1 (T1a, T1r, T1m)	Blade on top of T or L-shaped haft	1	T1	-	5
T1b	Blade on top of T or L-shaped haft, set in bifurcation	2	T1	E	3

Sleeved forms

MS	Sleeved blade, fixed mortise-and-tenon fashion	4	T4	A, B, C	1 (axe) 2(adze)
TS	Sleeved blade on top of T or L-shaped haft	1,2	T2	D	-
TvS	Sleeved blade over a projection from a T or L-shaped haft	3	-	C	4

*Suter's paper focuses on sleeved forms from the European Neolithic, using deer horn

Blade attachment

I distinguish three patterns (Fig 2):

- F** Folded: blade enclosed in a wrap-around cane handle (Crosby's T3)
- M** Mortise-and-tenon: blade set in a hole in a strong wooden shaft (Crosby's T3)
- T1** Top-mounted: blade mounted on top of a T or L-shaped haft (Crosby's T1)

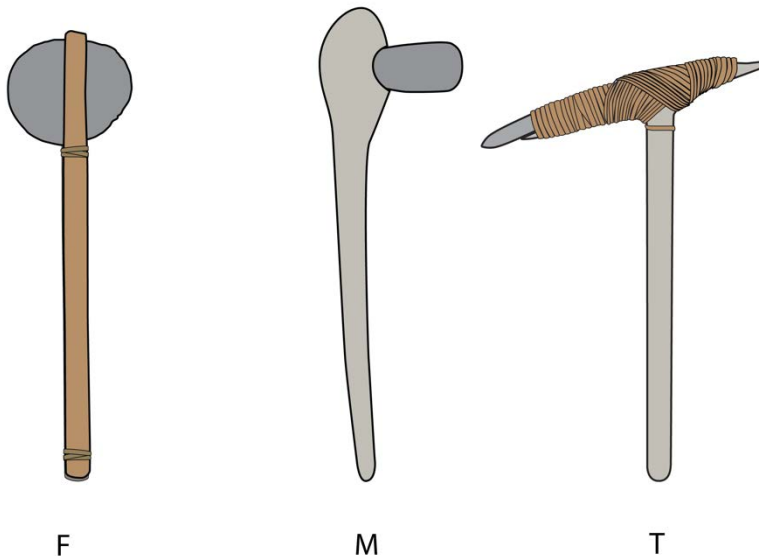


Fig 2: blade attachment patterns

Of Crosby's four types, I retain T1 as a designation for blades attached directly to the top of a T or L-shaped haft. This is the most widespread type in the AP region. Most (but not all) of these tools are adzes.

Blade angle

The second consideration concerns the angle of the blade in relation to the haft. A blade may be mounted as an axe (cutting edge parallel to the haft), or an adze (cutting edge at 90 degrees to the haft), or at some intermediate angle. Blades are rarely mounted at exactly 0 degrees or 90 degrees to the haft, but in most cases the deviation is no more than about 10-20 degrees and it is therefore still possible in most cases to characterize the tool as an 'axe' or 'adze'.

Direct vs sleeved (S) hafting

The third consideration is whether the blade is hafted directly (the default method) or is sleeved (S types). A blade can be attached directly to a haft, or it can be mounted in a sleeve that extends and protects the blade, which is attached to the haft (Fig 3). The sleeve may be bound at a fixed position in the haft, but in some cases rotating sleeves allow the angle of the blade to be adjusted while the tool is in use.

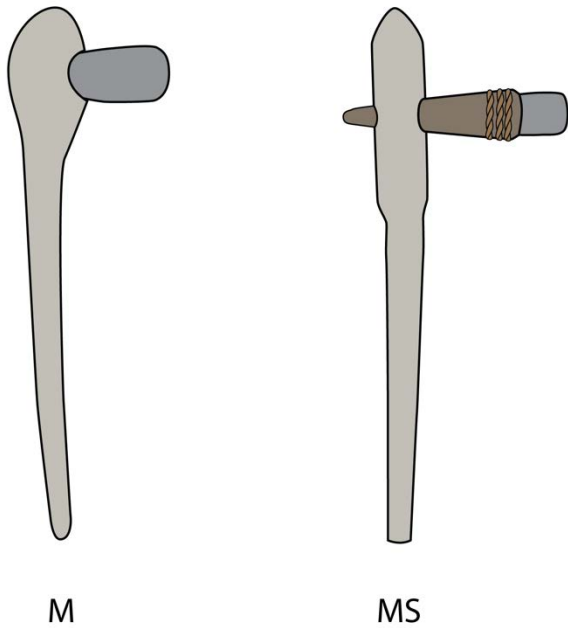


Fig 3. M axe (left), and sleeved MS form (right)

Blade form and material

Lastly I consider the shape of the blade and the technique by which it was made, distinguishing five types (Table 2).

Table 2: Blade types

Blade shape	Primary shaping technique	Finishing technique
Oval, waisted	Flaking	None, or edge grinding
Lenticular	Flaking, pecking	Grinding
Quadrangular	Sawing	Grinding
Shouldered (ie quadrangular with butt modifications)	Sawing	Grinding
Planilateral	Sawing	Grinding

As noted, the lenticular, quadrangular and shouldered blades are Heine-Geldern's original categories (Fig 4).

Oval, waisted blades are types found in Australia and in archaeological contexts in New Guinea, presumed to have been hafted as axes. They are generally flattish in cross-section and many are rather roughly shaped. Some have waists or butt-modifications to assist with hafting.

Planilateral blades are finely-worked blades with a flat cross-section, generally made by sawing flat slabs of rock. They have a variety of shapes, including tapering shapes and flaring forms

with crescent-shaped blades. Some of these shapes overlap with quadrilateral blades, many of which also have thin profiles. This form seems to have been invented independently in the highland region of PNG and was an important type in the Mt Hagen and Wahgi Valley regions, where it was employed for practical and ceremonial blades (Adam 1953, Chappell and Strathearn 1966, Burton 1984 and 1985).

These blade categories are useful for descriptive purposes, but a significant proportion of blades fall between categories. Fortunately, it is not necessary or useful to create a typology that lists every possible combination of hafting type and blade shape, because most hafting styles are associated with a limited range of blade types.

As far as material is concerned, the most common types are stone and shell. Blades of other materials such as bone and turtle shell are occasionally encountered.



Fig 4. Above: axe blades with oval-lenticular cross sections, Neolithic, Chifeng region, northern China. Below: adze blades with flat, quadrilateral cross-sections and profiles, surface finds, East Java. Tracing Patterns Foundation collection.

Morphospace

The typology of hafted tools outlined above is empirical: it is based purely on what is actually found. In order to compare the forms that are found in practice with what is possible in principle it is useful to consider the morphospace.

The morphospace is the set (space) of theoretically possible forms

For hafted tools, the morphospace consists of the theoretically possible configurations of a stone or shell blade attached to a haft, including every possible combination of blade shape, haft length and design and attachment method. It is therefore vast, and only a very small subset of it consists of practical, use-able tools. Defining the entire morphospace of hafted tools is unfeasible, but the attributes set out above can be used as the basis for mapping a part of it. Taking the attributes 1-3, combined systematically, generates 12 combinations:

3 hafting styles x 2 blade orientations (axe, adze) x 2 attachment styles (direct, sleeved) = 12 possibilities.⁵

These combinations are shown in [Fig 5](#).

Of the twelve possible varieties that make up this portion of the morphospace, eight hafting styles are actually found in the AP region. There are notable absences, such as the M-adze: in principle this is a tool with a blade directly hafted into wood handle with the blade at right angles to the handle. The reason for its absence is practical: a blade hafted in this way would have to be very long in order to ensure that the blade connects with the working surface when it is swung (rather than the end of the haft colliding with the working surface first). Such a long stone blade oriented in this way would be liable to fracture where the blade meets the handle, since the greatest stress would be applied across the weakest (thinnest) axis of the blade.

Similarly, folded cane handles (F types) are only found in association with certain rounded or oblong axe blades, probably because this hafting method is not strong enough to withstand heavy-duty work for long.

Beyond highlighting these practical considerations, the morphospace concept will be useful for a systematic evaluation of convergent evolution in hafted tools, considered below.

⁵ Compare a similar exercise by Crosby (1977: 89) with 9 combinations.

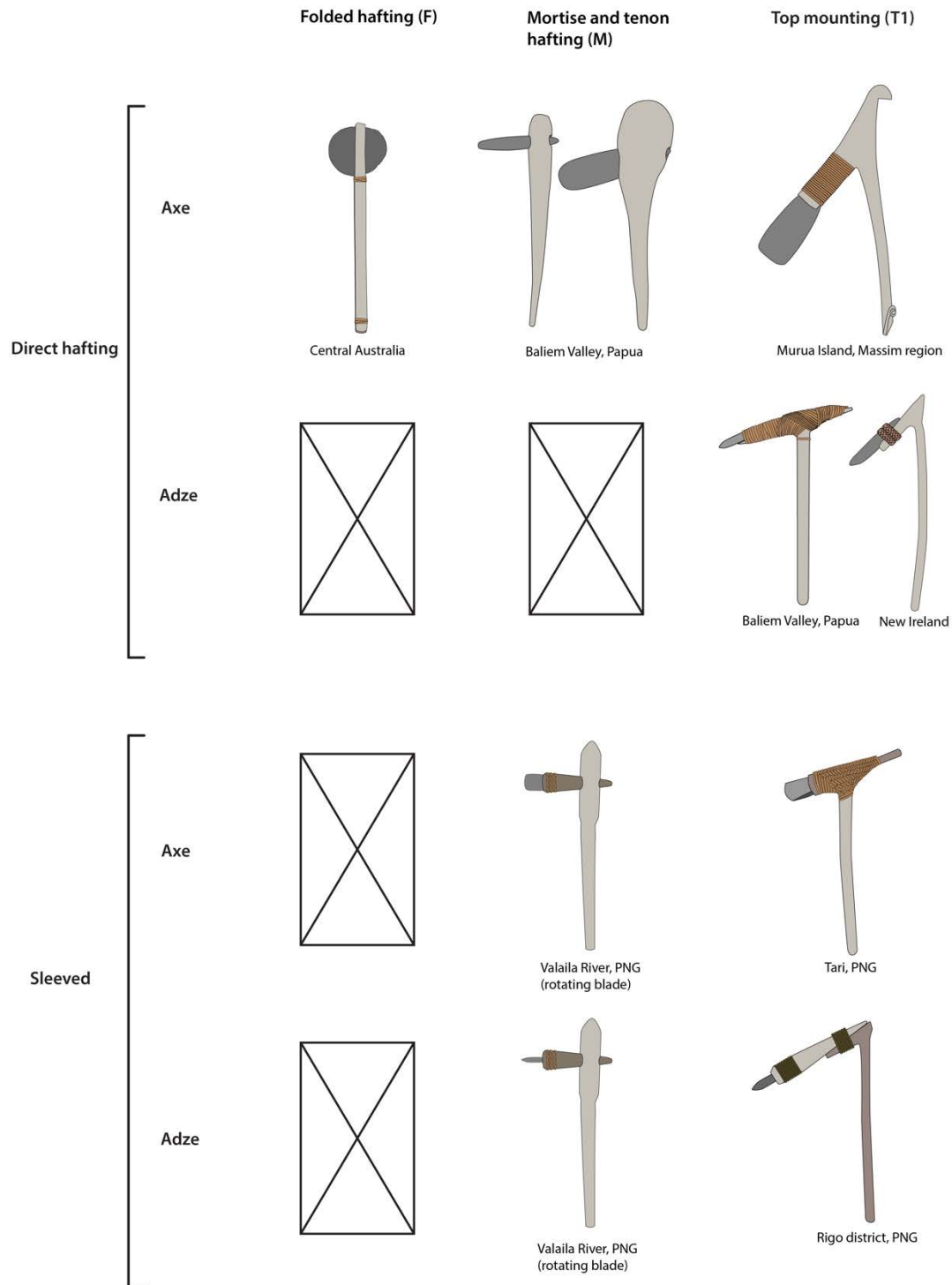


Fig 5. A partial morphospace of hafted tool variations based on three attributes, with forms from the Asia-Pacific region superimposed. Black squares indicate forms that are possible in principle but unfeasible in practice.

3. Hafted tools in the Asia Pacific region: survey

As noted, the data for this survey combines examples of tools from several sources:

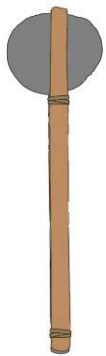
1. The Appendix to Eleanor Crosby's PhD thesis (Crosby 1973b).
2. Pierre and Anne-Marie Petrequin's book 'The Ecology of a Tool', which includes information on the distribution of tool types in Papua (Petrequin and Petrequin 2020: 26-37).
3. Around 100 examples of hafted tools from the Pitt Rivers Museum in Oxford; the British Museum; The Hearst Museum in Berkeley, California; the Wereldmuseum online collections in Holland; The Museum of New Zealand; The Bernice P Bishop Museum; The Auckland Museum; The Field Museum in Chicago; The Musee du Quai Branly; The American Museum of Natural History; The Pennsylvania Museum. These examples are listed in an excel spreadsheet in the supplementary material.

Most of the tools consist of stone or shell blades attached to wooden handles. In Island Southeast Asia shell and stone blades have not been used within living memory (though archaeological examples of such blades are plentiful), so I have recorded tools with metal blades that echo the shapes of stone blades (skeuomorphs), which presumably reflect earlier stone and shell hafting styles.

There are obviously many biases in this sample of this kind. The two most obvious ones are an emphasis on impressive tools, particularly wealth objects and ceremonial objects, and a bias towards coastal regions in the earliest collected objects, since most visitors traveled by boat.

I begin by enumerating the main types, before moving on to describe their distributions.

3.1 Tool types



F-axes (folded hafting)

The stone blade is disc-shaped, ovoid, or oblong. It sometimes has a waist or butt modification to aid hafting. The handle is constructed by folding a piece of split cane over the tool and binding the folded halves together to make a grip, resulting in axe orientation. Ethnographic examples from Australia are often reinforced with spinifex gum to improve the (otherwise rather weak) attachment of blade to handle.



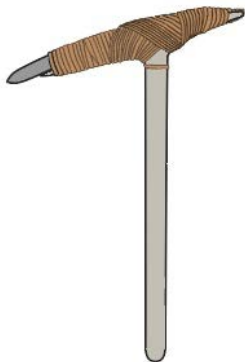
M-axes (mortise-and-tenon hafting)

This type consists of (most commonly) a lenticular blade directly hafted into a hole in a strong wooden or bamboo handle, the hole being shaped precisely to accommodate the blade. Stone blades are invariably mounted as axes rather than adzes in this type of haft.

F-axes and M-axes are combined together in Crosby's T3 tradition; they are distinct types with different uses and distributions, however.

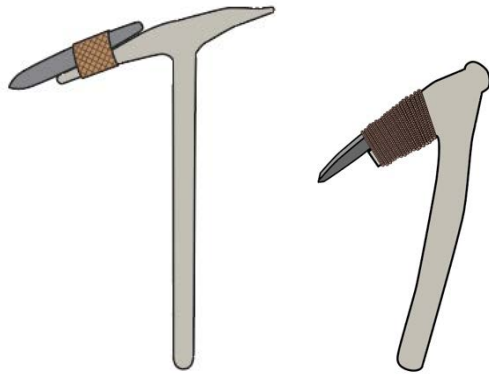
T1 forms (top hafting)

These types consist of blades attached to the top of a T or L-shaped haft. I retain Crosby's T1 code for them, dividing them into sub-types according to details of how the blade is attached to the haft.



T1a-adzes

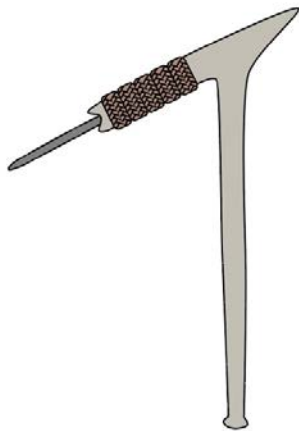
A lenticular or plano-convex (flattened-lenticular) blade lashed to the top of a T-shaped or L-shaped haft, the blade being oriented horizontally (adze-fashion), or at a slight angle to the horizontal. The handle may be flat on the top face or may have a step behind which the blade is set. Most hafts have a distinct 'heel' opposing the 'toe' where the blade is set. Split cane lashing extends across both the toe and the heel, covering this part of the tool and binding the blade to the haft. The blade is sometimes cushioned with leaves or bark, and tree resin is sometimes used to prevent it falling out.



T1r-adzes

A lenticular or quadrangular stone or shell blade, attached to the top of a T-shaped or L-shaped haft, oriented horizontally (adze-fashion), or at a slight angle to the horizontal. The handle may be flat on the top face or may have a step behind which the blade is set. The blade is secured with one or more rings of plaited fiber, or a band of lashed string or rattan. These materials are arranged so that the binding tends to be pushed up the handle (tightening it) when the adze is used. Some handles possess a definite 'heel', but this is absent on other examples. The fiber used for fixing depends on whatever is available locally.

This category includes a wider range of types than T1a and could be further sub-divided.



T1b

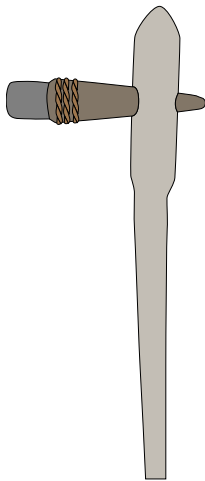
A lenticular stone blade of flattened profile, set into a split or hollow in the top of a T-shaped or L-shaped haft. The blade is secured with rings of plaiting or lashing. This type is found in a few regions in New Guinea.



T1m-axe (Massim type)

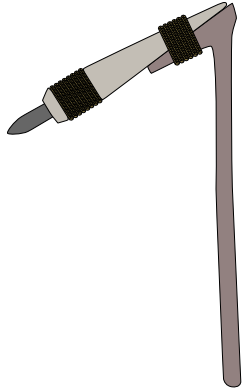
Planilateral blade, set into the top of a T-shaped or L-shaped haft, usually with a wooden cover over the blade, secured with cord lashing.

This type is confined to the Massim region (at the southeastern tip of PNG) and a few offshore islands. Most axes that are known of this type are ceremonial forms used as wealth/ trade items.



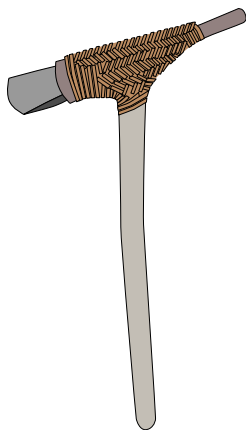
MS

These tools consist of a lenticular blade set into a wooden sleeve, the sleeve being made from one or two pieces of wood bound with split cane rings. The sleeved blade is set into a hole in a strong wooden handle. This type is an elaboration of the M-axe that allows a shorter stone blade to be hafted. Unlike the M-axe, the blade can be set at any angle (axe, adze or in-between).



TSr (rotating blades)

This tool is similar in principle to the MS form, except that the sleeved lenticular blade is attached to the top of a T or L-shaped haft. Like the MS form, the angle of the blade can be adjusted freely.



TSf (fixed-blades)

This type consists of lenticular or planilateral blades fitted into a wooden sleeve, bound to a T-shaped handle with lashing and/or plaiting. Once bound, the angle of the blade cannot be altered without dismantling the binding, unlike the TSr rotating form. Most TSf tools were hafted as axes, but some were hafted as adzes, and some tools were hafted at intermediate angles (Steensberg 1980: 1-43). This type was confined to the Central Highlands of New Guinea and nearby regions. It includes many wealth/ceremonial forms.

Distribution

The distribution of tools across the entire AP region is shown in [Fig 6](#).

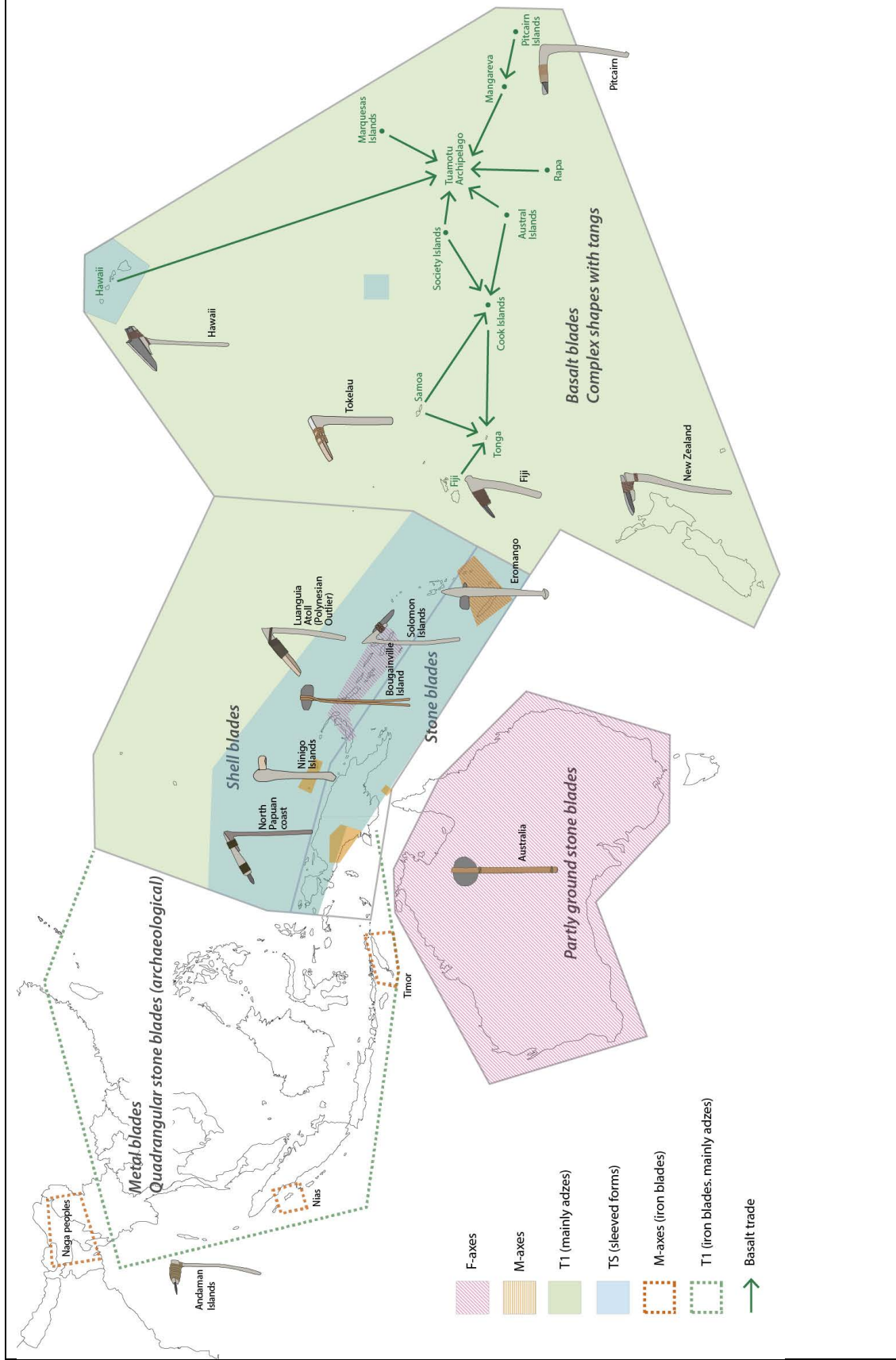


Fig 6. The distribution of the main types of hafted stone tools in the Asia-Pacific region.

In the following sections I describe the hafted tool types region-by-region, with a brief summary of relevant archaeological findings.

3.2 Island Southeast Asia

Hafted stone tools had mostly disappeared across this region before colonial times, with the possible exception of the interior of Borneo (Steensberg 1980:25). My remarks are therefore confined to a brief overview of archaeology, and a note on iron tools. This is presumed to be the source region for tools that were subsequently carried to the east by Austronesian-language speaking settlers.

As noted, the earliest fully ground blades on the Asian mainland were blades with oval or teardrop shapes in plan-view, and lenticular or oval cross-sections. Ground stone blades with complex shapes (quadrangular and shouldered forms) first appeared on the southeast Asian mainland around 8kya. From around 5kya onwards they began to appear in ISEA, where they are associated with the expansion of Austronesian language speakers, fishing and farming peoples who originated on the mainland. These blades were almost certainly hafted as T1-adzes, and were used for agriculture and woodworking, including boat-building.

As mentioned, such tools had mostly disappeared across this region before colonial times, However, early iron tools preserved in Dutch Museums are hafted in similar ways to ethnographic stone tools. The majority are attached to the top of a T or L-shaped haft by means of lashed cane or plaiting work. The blades, which are mostly flat quadrangular blades with a tang, were presumably locally made and pre-date imported European forms (Fig 7). Most were oriented as adzes, a few as axes. These tools, considered together with the archaeological data, suggest that the T1-adze has been the dominant form in ISEA for at least the last two millennia.

M-axes were occasionally encountered, mainly in remote locations. A single M-axe is known from the island of Nias, off the northwest coast of Sumatra (Wereldculturen Museum RV-3600-1566), and an early photograph from the island of Timor shows a man holding an M-axe. Both of these axes had metal blades that echo stone blade shapes. Similar M-axes were also collected from Naga peoples living in what is now Bangladesh.

I discuss the Timor axe, which is extremely interesting, in the context of New Guinea tools.



Fig 7. Adze from Minangkabau region, Indonesia. Wood handle, metal blade attached with split cane lashing. The handle is 40cm long and the iron blade is 14cm long. Wereldculturen Museums RV-268-372, accessioned in 1881. Creative Commons 4.0 International License.

3.3 Andaman Islands

Several adzes were collected by early visitors to the Andaman Islands, including an example in the Pitt-Rivers Museum collected in 1932, adzes in the Wereldculturen Museum (RV-816-19) and the British Museum (As1905,0313.54-55). All of these adzes have beaten metal blades attached to T1 hafts, with wooden covers over the blades, lashed with split vine material. They are said to be based on earlier prototypes with shell blades. The Andaman Islanders, speaking a language isolate, are thought to have had relatively little contact outside their home archipelago, so their T1 adzes may represent an independent invention.

3.4 Australia

Australia and Near Oceania were first settled by people speaking the forerunners of Australo-Papuan languages, between around 60kya and 25kya. Until around 9kya Australia and New Guinea were part of a single continent (Sahul), the two becoming separate as a result of sea level rises following the end of the last ice age. Early settlers crossed from the continent of Sundaland through the island archipelago of Wallacea to reach Sahul, and possessed seaworthy boats. They brought flaked tool technologies with them, and probably other technologies, such as string and cord usage, bows and arrows, and bamboo knives, though little trace remains of such organic materials.

As noted above, edge-grinding was invented at a very early date in Australia. Despite this, the technique seems to have occupied a peripheral role in Australian stone tool-making, which was dominated by flaking technologies. Nevertheless, axe heads, generally disc-shaped or oblong, with signs of edge grinding, some of which had waisted shapes to aid hafting, were produced in

all parts of Australia (Akerman 2014). Examples collected during colonial times have hafts that consist of a piece of cane folded over the axe head and secured with lashed bindings around the hafts (F-axes). Some axe heads are also partly covered in spinifex gum in order to make a more secure attachment to the handle.

The Australian axes seem to have been occasional-use items that were not made by all groups. Hayden (1977) interviewed indigenous elders in the Western Desert region who could recall making and using stone tools, but none mentioned hafted axes. Hayden found that his respondents preferred to use 'found' stones that had sharp edges, picking them up and discarding them as they went along. Steensberg (1980: 41) reproduces a photograph of an indigenous man from the Pitjendadjara tribe using a 'found', unmodified stone to cut a tree in exactly this way.

A use-wear study of Australian axes by Attenbrow and Kononenko (2019) suggests that these tools had several different functions, including woodworking and processing skin and bone items.

3.5 Melanesia and Micronesia: offshore islands

The most complex mixture of ethnographic hafted tools in the AP region was found in New Guinea and the offshore islands, including the Admiralty Islands, New Ireland, and New Britain. These will be discussed below, together with the island of New Guinea itself.

Moving further offshore, into the islands of Micronesia, the range of types diminished. In this region the main tool, as in Polynesia, was the T1r-adze, mainly hafted with a blade made from Tridacna or Terebratula shell, stone being relatively rare on coral atolls. These were lashed to wooden handles with a short heel or no heel at all, using string made from locally available fiber sources such as grass or coir. Some blades, particularly those made from large Tridacna shells, were well-finished; others were made from barely-modified portions of shell.

A few tools were made using sleeved blades (TS types), such as an adze from the Caroline Islands in the Musee du Quai Branly (accession number 72.60.707), and a partial adze from Sonsorol Island in the Field Museum in Chicago (accession number 252589). These forms were less common in the remote islands than on the islands near to New Guinea.

Adzes from the 'Polynesian Outliers' group are discussed in the Polynesian section below.

3.6 New Guinea

I begin with an overview of the geographical features and languages of New Guinea as these are key for understanding tool distributions.

Geography

The outstanding feature of this large island is an upland region that extends for most of its length, with chains of mountain peaks interspersed with deep, wide valleys carved by glacial action. Though New Guinea is situated in the tropics, the bulk of the pre-contact population

lived in this upland region, which has a warm temperate rather than a tropical climate. This region is free from malaria and is far more hospitable than the coastal plains. The natural vegetation is a mix of temperate species such as oak and beech, and tropical plants such as palms, rattan, pandanus, and native banana species, which are able to grow in the cooler upland regions because of the absence of frosts. The highland valleys provided excellent conditions for year-round agriculture, and at time of first contact with western outsiders, regions such as the Baliem Valley, and the Wahgi and Jimi Valleys supported the highest population densities on the island.

Language

Much of New Guinea is populated by people speaking Papuan languages, which are assumed to be descended from languages spoken by the earliest settlers on the island, who arrived at least 40,000 years ago. Languages tend to change and diverge over time, and 10,000 years is considered to be long enough for similarities (particularly cognate forms) to fade away completely, with the consequence that Papuan languages consist of a great many groupings that appear unrelated. Within this diverse group, however, one major grouping, that of the Trans-New Guinea (TNG) languages is recognized as a single language family by most linguists. It consists of languages spoken over a region that follows the highland interior of the island. Different and more diverse groups of Papuan languages are spoken along Sepik River, the coastal plain in the northeast of New Guinea, and in the Fly River region to the south.

Linguist Andrew Pawley (1998, 2005a, 2005b) pointed out that the distribution of the TNG corresponds closely with that of upland farming practices and suggested that the expansion of this group was therefore probably linked to farming, and that the initial divergence in the TNG languages began between 9000 and 6000ya, concurrent with the invention and spread of agriculture on New Guinea. These languages spread beyond New Guinea to the nearby islands of Timor, Alor and Pantar.

The distribution of the TNG language family is shown in the map in [Fig 8](#). Most linguists concur with the broad distribution of TNG languages outlined here, but there is some debate about whether the languages of the Central Highland region of PNG, such as Enga and Chimbu-Wahgi, belong to the TNG family, or not.

In the last three millennia, speakers of Austronesian languages arrived in Melanesia by boat. As (relatively) late-arrivals, with an orientation towards seafaring and fishing, they mainly occupied enclaves on the north coast and parts of the southeastern peninsula. Most did not penetrate far into the interior, finding that those areas were already occupied by Papuan farmers. As latecomers, the languages spoken by these groups are more closely related to each other than Papuan languages are to each other.

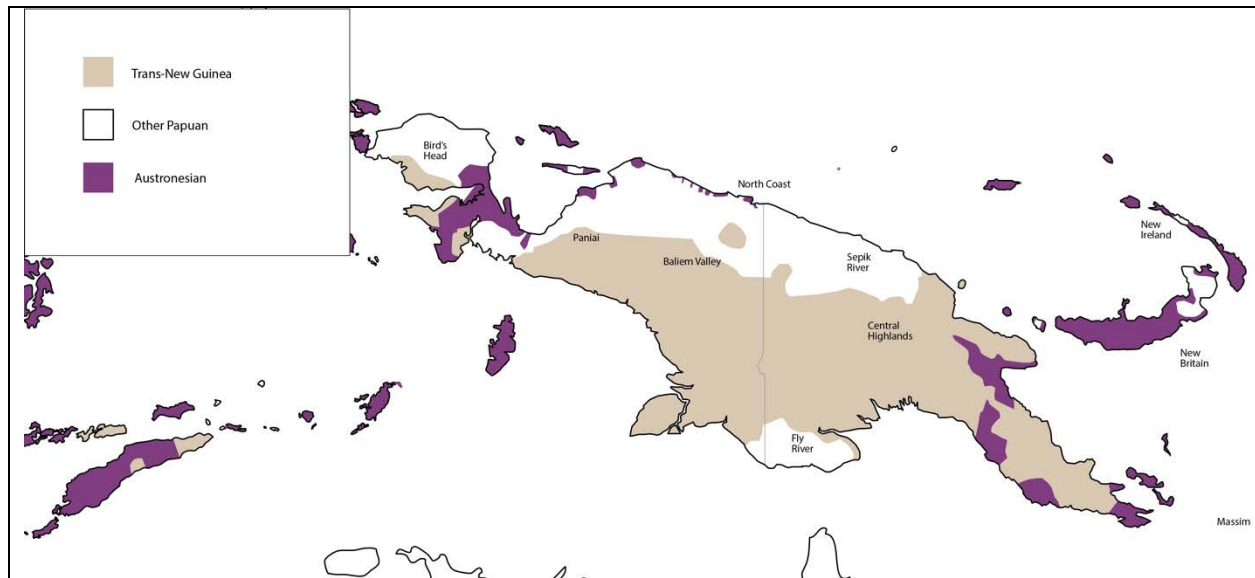


Fig 8. Language families in New Guinea and surrounding region. After Ross (2017) and Schapper (2020).

Archaeology

Ethnographic examples of F-axes were confined to some of the offshore islands in Melanesia, but archaeological finds show that this type was once present in the main island of New Guinea as well. The oldest known stone tools in New Guinea come from the Ivane Valley in PNG (Ford 2017), an upland area that includes the archaeological site of Kosipe. A variety of flaked (but not ground) tools were found there that date from between 49kya and 43kya, including waisted forms that were presumably hafted as axes. This shows that the first settlers in New Guinea penetrated the highland region relatively early, perhaps to hunt game and exploit forest products such as Pandanus nuts. Large flaked and waisted axes have also been found at a coastal site in the Huon peninsula (Groube et al 1986), dating from around 40kya. On the coast there is evidence for the use of obsidian for making tools around 39kya at Kupona na dari in New Britain (Summerhayes et al 2009), implying an early trade in this valuable material.

Susan Bulmer, who excavated inland sites at Yuku and Kiowa, discovered that blades that she called 'Type 1 waisted/ butt-modified' axes were present in some of the earliest archaeological sites in the central highlands of PNG associated with human presence (Bulmer 2005). This includes sites in the Wahgi Valley and neighboring regions, such as Kosipe from around 30kya, and at Yuku between 17900 and 5700ya. These tools seem to have been used for seasonal foraging activities in forested regions. Not all of these early blades were conclusively used with hafts, but she considered that the presence of waist and/or butt modifications to be indications of the use of wrap-around handles. Such tools were probably used in a similar way to ethnographic Australian axes, as light-duty chopping tools. These axes disappeared from the archaeological record around 6kya.

The locations of key sites are shown in Fig 9.

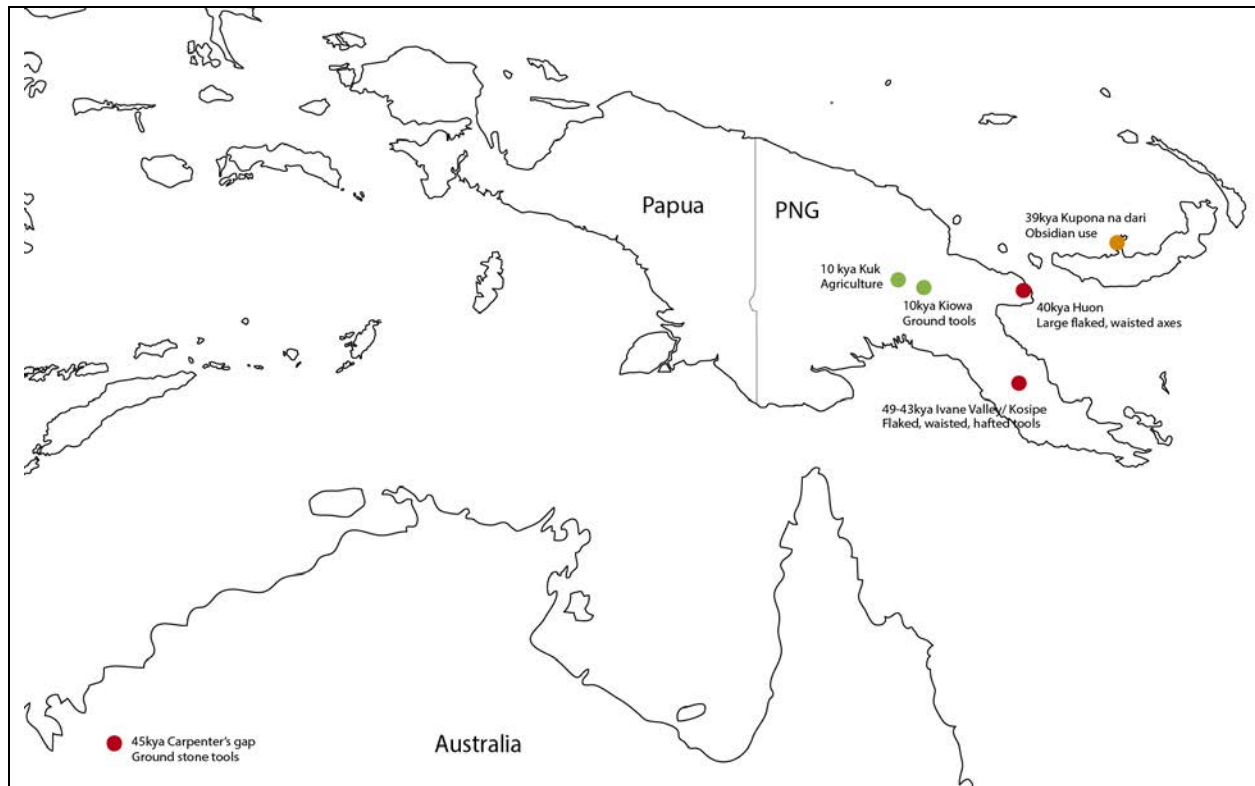


Fig 9. Locations of archaeological sites referred to in the text.

Evidence from excavations at Kuk swamp in the Central Highlands of PNG by Jack Golson and colleagues (Golson et al 2017) demonstrates that agriculture, involving the cultivation of taro and banana, emerged gradually in this region from around 10-9kya onwards. Golson links the transition to agriculture to the emergence of new types of stone tool, including ground and polished axes with lenticular profiles, mortars and pestles, and a chert tool with traces of fiber wrapping. The archaeological examples of these stone tools are essentially indistinguishable from ethnographic tools (minus their hafts) that were in use until recently in the Baliem Valley and Wahgi Valley regions.

Ground and polished axes with lenticular profiles become increasingly common across New Guinea and the nearby islands from around 12-11kya onwards. Excavations at the Kiowa rockshelter, another inland site, uncovered both flaked and ground tools, including the use of high quality polished volcanic stone axes, apparently sourced from some distance away (Gaffney et al 2015). The assemblages of tools, consisting of a few polished stone tools of high value and many flakes that were of low economic value but useful in daily life, is a pattern that can be seen in recent ethnographic studies of New Guinea tool use.

Research on Obi Island in Wallacea similarly found evidence of offshore use of ground shell artifacts from around 8kya onwards (Shipton et al 2020).

From a slightly later period, research at the Central Highland site of Waim in the Jimi Valley found evidence for the manufacture of lenticular blades (presumably by flaking/chipping) but also planilateral blades with more complex shapes, produced by sawing tabular stone (Shaw et al 2020). The Waim assemblage is neolithic in character, and includes mortars and pestles, ochre used as a coloring material, club-heads, and evidence of exploitation of yams and bananas. This site significantly pre-dates the arrival of Lapita peoples (Austronesian language speakers) in New Guinea at around 3200ya.

Overall, there is evidence for the gradual development of 'neolithic' characteristics in New Guinea, including a transition to agriculture and the use of polished stone tools, occurring independently from similar developments in other parts of the world. While these developments were underway, lifeways in neighboring Australia remained centered on hunting and gathering, with a different set of stone tool technologies. In both locations these technologies persisted until the recent past.

Ethnographic tools in New Guinea: direct hafted types

The distribution of direct-hafted tool types, in which blades are set directly into or onto a wooden haft (F, M, T1) is shown in [Fig 10](#). These tools, which are assumed to include the oldest types, are found mainly in the interior provinces of New Guinea (where they are the principal types), with occasional occurrences in the offshore islands (Admiralty Islands, New Ireland, New Britain), where they are assumed to be remnants of types that were once more widely distributed.

F-axes

As mentioned, F-axes are absent in New Guinea, but were encountered by early travelers in New Britain, Bougainville Island and New Caledonia. Some of these appeared to be practical tools, others, such as distinctively shaped axes with twisted cane handles from Bougainville, appear to have been wealth objects.

M-axes

The M-axe, though generally uncommon in the Asia-Pacific region, was the main type of hafted tool in the south-western coastal region of New Guinea, amongst people speaking Asmat-Kamorro languages (part of the TNG language family). In this region lenticular stone blades were fitted into wood and bamboo-culm handles and were used for tree cutting. Some axes had ceremonial and/or wealth significance, judging from the elaborately carved handles on Asmat examples. M-axes were also found in the Baliem Valley, where they were the main tools of groups including the Wano, Moni, Dem and Damal living in or near the western end of the Valley. Amongst the Dani people they were occasional tools used for splitting firewood. The M-axe was also found in a few offshore islands to the north (Ninigo Islands, Hermit Island and Kaniet Island) and Murray Island in the Torres Strait region. These axes were mainly fitted with shell blades.

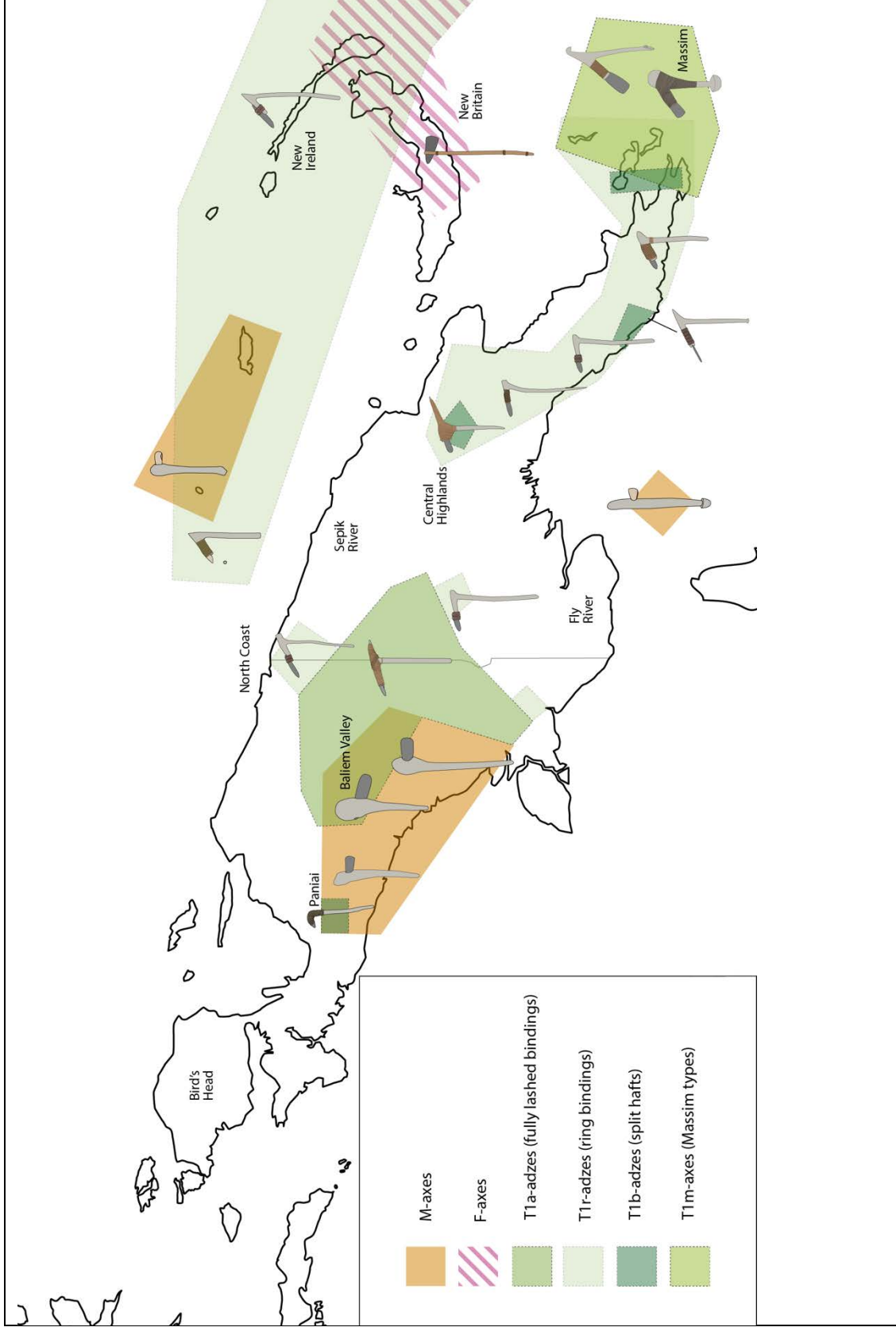


Fig 10. The distribution of direct-hafted stone tools in the region of New Guinea.

The Asmat peoples living in the southern coastal plain were not farmers: their lifestyle was based on gathering wild sago and hunting pigs. They used M-axes for tree-cutting and for making planks for housebuilding. The Wano were shifting horticulturalists, growing crops on mountain slopes and hunting for game in the surrounding forests. Like the Asmat, they used M-axes mainly for tree felling and splitting planks and firewood (Petrequin and Petrequin 2020).

T1-adzes

T1 adzes were found in two main groups in New Guinea. Fully-lashed T1a adzes were found across a large, contiguous region in eastern and central New Guinea, stretching from the Baliem Valley to the western edge of the central highland region in PNG. Across much of this range, inhabited by speakers of Trans-New Guinea languages, it was the only hafted tool. Most of its users, such as the Dani and Yali peoples, were dedicated farmers, growing sweet potato in intensively farmed fields in the valley floor, and intermittent plots in cleared areas on the valley sides. Adzes were essential tools for clearing these plots, work that was done mainly by men. My T1a group mainly comprises Crosby's Western Interior 1 and 2 types. Within this group, the angle between the haft and blade and the length of the heel varied (both within groups and between groups), as did details of the lashing technique. Most blades were lenticular or flattened-lenticular in profile, but adzes used by Yali and other groups living just to the east of the Baliem Valley, had convex-triangular rather than lenticular profiles. Aside from these differences, the T1a adze was a remarkably consistent tool across this inland region. A few T1r adzes, with blades held with plaited rings and similar arrangements, were found on the eastern and southern fringes of the T1a region (see map).

In southeastern Papua, the peninsular region sometimes referred to as the 'tail' of the bird, a more varied mix of T1 variants were used, alongside other types such as sleeved-blade tools (discussed below). The complex patchwork of tool types in this region presumably reflects a more complex population history than the T1a region in the west. The region includes speakers of both Papuan and Austronesian language speakers. The latter group are assumed to be descendants of Lapita peoples who settled along the southern coast around 3000ya.

The most common tool type along most of the peninsula, from the Central Highlands to the Massim, is the T1r adze, with lenticular or planilateral blade secured with plaited ring bindings, or cane lashed around the front (toe) of the adze. Alongside these tools there are several variants with more complex construction. In three locations adzes are found where the blade is set into a hollow or a slot carved in the toe of the adze (T1b forms). At the far eastern tip of the peninsula and the offshore islands (Massim region) impressive ceremonial tools were made, with planilateral blades lashed against the side of a T-haft in axe-orientation (T1m form). In some versions a wooden cover was added to help to secure the blade against the haft. These axes probably descended from utilitarian tools, but by the time western visitors arrived most of the remaining axes were ceremonial objects or wealth objects, practical applications having been replaced by tools with imported iron blades.

Some axe blades were circulated as part of the Kula exchange ring in the region of the Trobriand Islands studied by Malinowski (1922). In the Trobriand Islands ceremonial axes retained a role as possessions of the 'magicians' who ensured the fertility of the fields: in 'Argonauts' there is a photograph of one of these magicians conducting a ceremony in a yam field, with a large axe balanced on his shoulder (Fig 11) which was presumably a 'badge of office'. Seligmann (1910) states that these ceremonial axes were called *benam* in the dialect of Tubetube (Slade Island) and were traded across the entire Massim region. He illustrates two axes with different haft styles (1910 PI LXI, PI LXII), both of which have thin, superbly-crafted stone blades (Fig 12). These blades were formerly made on the island of Murua (Muyua), but the craft of making these stone blades was said to be already extinct by the time of Seligmann's visit.



Fig 12 A magician with a large ceremonial axe conducts a ceremony in a field in the Trobriand Islands. After Malinowski (1922:406)



Fig 13 A ceremonial axe, *benam*, from the Massim region. After Seligmann (1910: PI LXII)

Aside from the T1 adzes (and some axes) found on New Guinea, T1r adzes were also found in the offshore islands to the north, part of the wider distribution of these forms across the Pacific region as described above. These adzes had a mix of stone and shell blades, depending on what was available to their makers. Most differed little from adzes of the same general type found in southeastern New Guinea.

TS and MS tools in coastal regions

These tools comprise TSr and MS forms, mapped in Fig 13. As is apparent from the map, these types were mainly found in coastal regions. This circumstantial evidence supports the general view that these types were particularly useful for hollowing out canoes since the blade could be easily rotated, which was an advantage when chipping away at the interior of a canoe. Photographs of canoe making on the southern coast of Papua support this idea (Fig 14).

As Petrequin and Petrequin (2020) pointed out, the TS hafted tools found on the north coast of New Guinea are similar in construction to sago pounders from the same region. The pounders were equipped with blunt, cylindrical stone bits. Some TS cutting tools and sago pounders had a length of cord that joined the handle to the blade-sleeve, perhaps to reinforce them.

MS forms were mainly found in the same region or regions adjacent to simple M-axes, supporting Crosby's view that MS is a development of the M-axe form. Most of their users spoke Papuan languages. Conversely, TS types tended to be found in coastal regions where Austronesian speakers are present (though these types were used by Papuan speakers as well). These links have not been investigated in any detail.

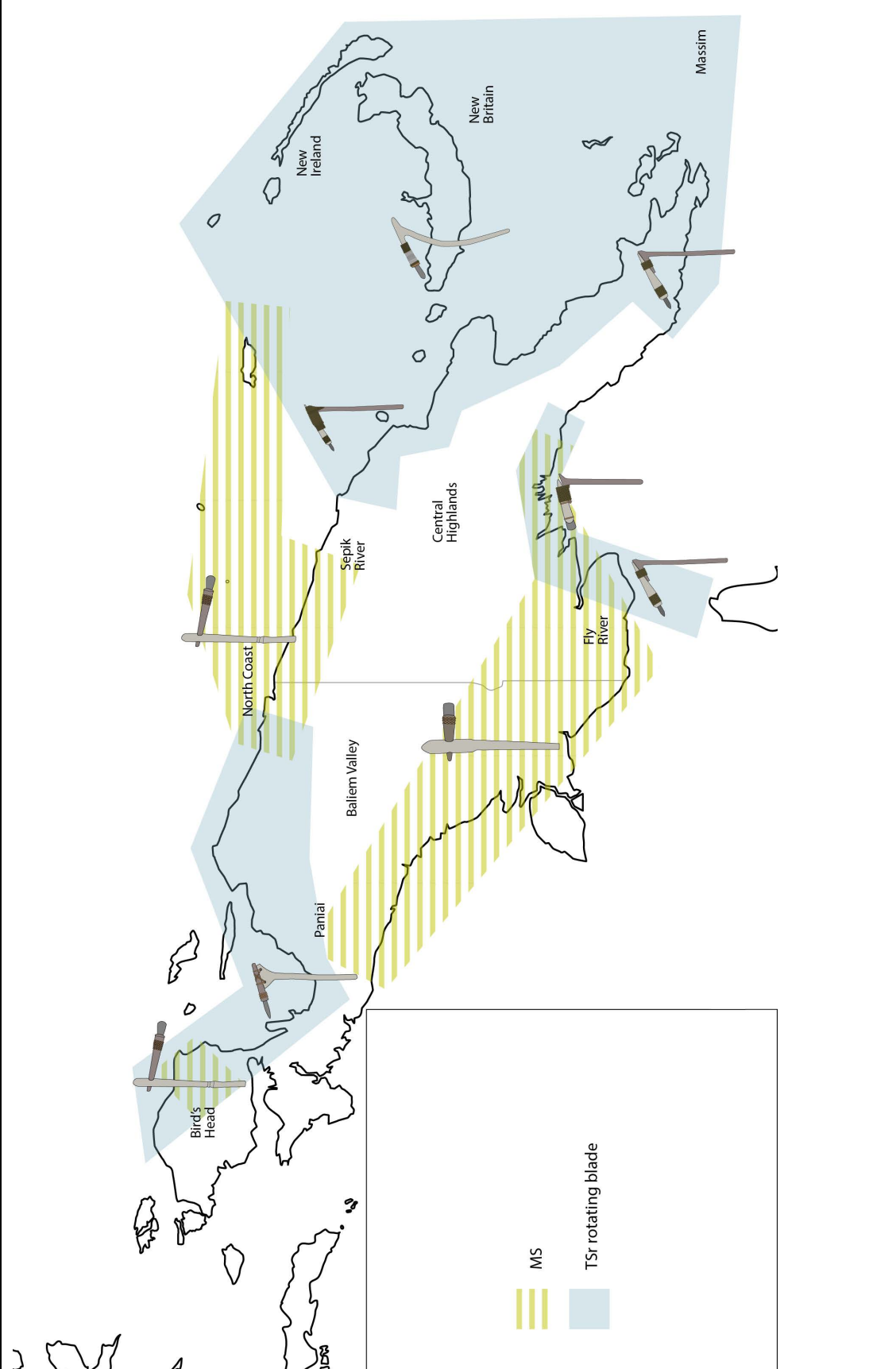


Fig 13. The distribution of direct-hafted stone tools in the region of New Guinea.



2.18.2.40.



2.18.3.42.



2.18.3.48.



2.18.3.50.

Fig 14. An Asmat man using an MS axe to hollow out a canoe at Amanamkai, 1960-61, showing how the sleeved blade can be reset at will while working. The blade appears to be metal. Photographs by A.A.Gerbrands, Wereldmuseum RV-10389-23. Creative Commons 4.0 International License.

TSf tools from the Sepik River and Central Highlands

The TSf forms were confined to an important region in the Central Highlands of New Guinea and the Sepik River region, extending down to the coast (Fig 15). They resemble TSr forms found in coastal regions (from which they may be descended), but the sleeved blade in most of these tools is firmly lashed to the haft and cannot be rotated without dismantling the lashing. This type of tool could be oriented as an axe or an adze (or somewhere in-between), and a range of types were made. Adze versions were important for some users, though they were less-often associated with prestige blades and probably less-collected for that reason. In his study of the trade in stone blades and other materials in the Central Highlands, Ian Hughes recounts how 'A Daribi canoe-maker ... refused to part with his adze of dark green stone from the Abiamp quarry in the middle Wahgi Valley, saying that for finishing the inside of a canoe there was no substitute' (Hughes 1977:134).

In the Sepik River coastal region [Fig 15: region 1] rotating-clamp TSr forms (such as an adze from Aitape in the Musee du Quai Branly, accession number PP0103212) existed alongside TSf forms oriented as axes, such as an example from the Torricelli Mountains described by Crosby (1973b:161, Sepik 4 type). Inland, TSf forms with fixed blade orientations predominated, such as the 'Sepik 8' type described by Crosby (1973b:171).

TSf work tools with lenticular blades were made in the Kopiago region [region 2]. To the east of this region TSf axes were made with planilateral blades and a variety of shapes. In Engan language-speaking areas [region 3] axes had a heel shaped like a long, narrow 'fishtail' (Crosby's Central Interior 9 type), and similar forms were made in the area to the south [region 4, Crosby's Central Interior 10 and 11 types] with heels of varying lengths. Some of these, particularly attractive examples with thin planilateral blades, were probably wealth items.

Moving further to the east, 'Mt Hagen' axes (Fig 16) with plaited coverings, crescent-shaped planilateral blades and wide, flaring heels were made (or traded) across a large area that included Mount Hagen, the Wahgi Valley, Jimi Valley and Kaironk Valleys, extending eastwards almost to the coast [region 5]. These are regions mainly inhabited by people speaking Chimbu-Wahgi languages. The blades used in these axes came from quarries in the Jimi, Wahgi and Asaro regions. Most of the blades from this region surveyed by Hughes (1977:135-150), however, were working tools with profiles ranging from oval to teardrop-shaped and elongated-trapezoidal. A few of them exhibited the flaring shapes with crescent-shaped cutting edges that are disproportionately represented in blades in Western collections.

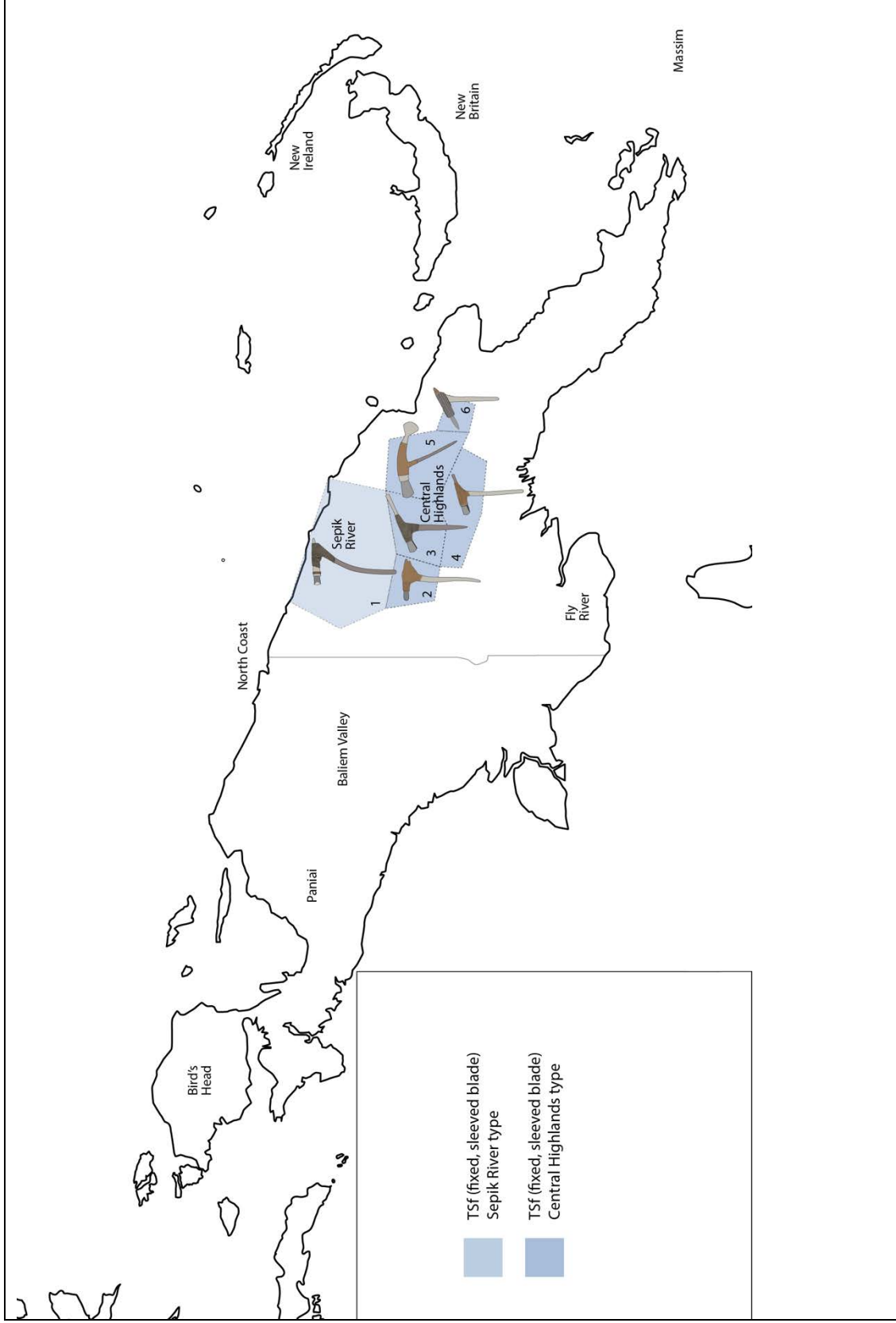


Fig 15. The distribution of fixed sleeved-blade stone tools in the region of New Guinea. For descriptions of sub-regions, refer to text.



Fig 16. Ceremonial axe from the Mount Hagen area, Papua New Guinea, 79cm x 79cm. Wereldmuseum WM-53024, accessioned in 1961. Creative Commons 4.0 International License.

Considered together, there existed a gradation of types that appears to recapitulate their development. This begins at the coast with TSr forms, continuing inland up the Sepik River and then inland towards Kopyago with TSf forms with 'conventional' lenticular blades, which become increasingly elaborate in both blades and hafting towards the east, culminating in the large, ceremonial Mt Hagen axes. This suggests long-standing cultural links between the coastal region, Sepik River drainage and the Central Highlands. The floodplains of the Sepik and Ramu rivers were once an inland sea, which gradually silted up and disappeared around 3000-2000ya. The ancient shoreline of this sea would have fostered more direct links between the coast and the Central Highlands at this earlier time (Swadling 1997).

Crosby suggests (1973a:305) that the occasional finds of T1-adzes in this central region imply that this was formerly the main type in the Central Highlands (as in surrounding regions to the east and the west), but these tools were gradually replaced by TSf forms. As Hughes (1977:176) discusses, this change was probably not driven by functional considerations, since the TSf forms with planilateral blades do not seem to be superior tools to T1-adzes. Rather, it seems to have been related to the production and trade of blades of value and prestige, which were displayed to their best advantage when oriented as axes in hafts with elaborate polls and plaited coverings. This form seems to have embodied the notion of 'the ideal axe' in the Central

Highlands region, maintained by cultural forces rather than practical constraints. As discussed, a similar presentation style was developed independently in the Massim Region, where large, thin blades were hafted as T1m axes for exchange and trade purposes.

Objects of wealth and status

The appearance of wealth-axes in the Central Highlands and Massim is part of a pattern seen across the island of New Guinea. In certain areas, particularly areas that were relatively prosperous, resulting from farming, fishing or trade, functional stone tools were elaborated into forms that became associated with wealth and status. In the Baliem Valley this took the form of *je* stones (Chapter xx this volume), which were accumulated and exchanged as part of ritualized gift-giving. In the Lake Sentani region, one of the few coastal regions where stone tools were made, greenstone blades were made that were solely for use as wealth items (Petrequin and Petrequin 2020:192). These blades were made from semi-translucent stones, highly polished and superbly finished (Fig 17). They were never hafted and were mainly used as part of bride-price payments, along with imported glass beads and glass rings.



Fig 17. Blades made in the Lake Sentani area as wealth objects, principally for bride payments, collected during the 1980s. The larger blade is 23cm long. Tracing Patterns Foundation.

The New Guinea interior: farming, language, and stone tools

Since ground-and-polished stone tools found in the interior of New Guinea were associated with land-clearance and farming, we expect to see the history of farming practices, and by extension, the farmers, reflected in the distribution of these tools. A review by Jack Golson (2005) supports Crosby's conclusions that M-axes the earliest tool, that their present-day distribution is a remnant from an early phase of agricultural expansion, and that the adze-using provinces in the highland region are developments that are independent of Austronesian incursions.

Summarizing the key observations by Pawley, Crosby, Bulmer, the Petrequeins, and others:

1. The expansion of the TNG language group was linked to the invention and intensification of farming in the highland region.
2. M-axes and T1-adzes with lenticular blades were the major agricultural tools associated with these developments, pre-dating the arrival of Austronesian language speakers.
3. The archaeological evidence from the Central Highlands and the Baliem Valley for land modification (drainage and forest clearance) begins around 10kya and intensifies after that time.

Despite the appearance of innovative tools, the replacement of older types by new forms in the highland region was slow, partly due to cultural conservatism and partly to physical factors. Objects were exchanged through local trade, but technologies such as tool production moved more slowly. Ian Hughes's study (1977) records an extensive trade in axe blades in the Central Highlands in pre-contact era, but even a few kilometers from axe quarries users had no knowledge of where the sources were or how the axes were made. The extreme slowness of technological change in the New Guinea highland means that tool distributions in the recent past continued to reflect (in part) ancient phases of agricultural intensification.

Putting these various elements together suggests that distribution of tool types in the highland region reflected three waves corresponding to the emergence and intensification of agriculture (Fig 18). The three waves are as follows:

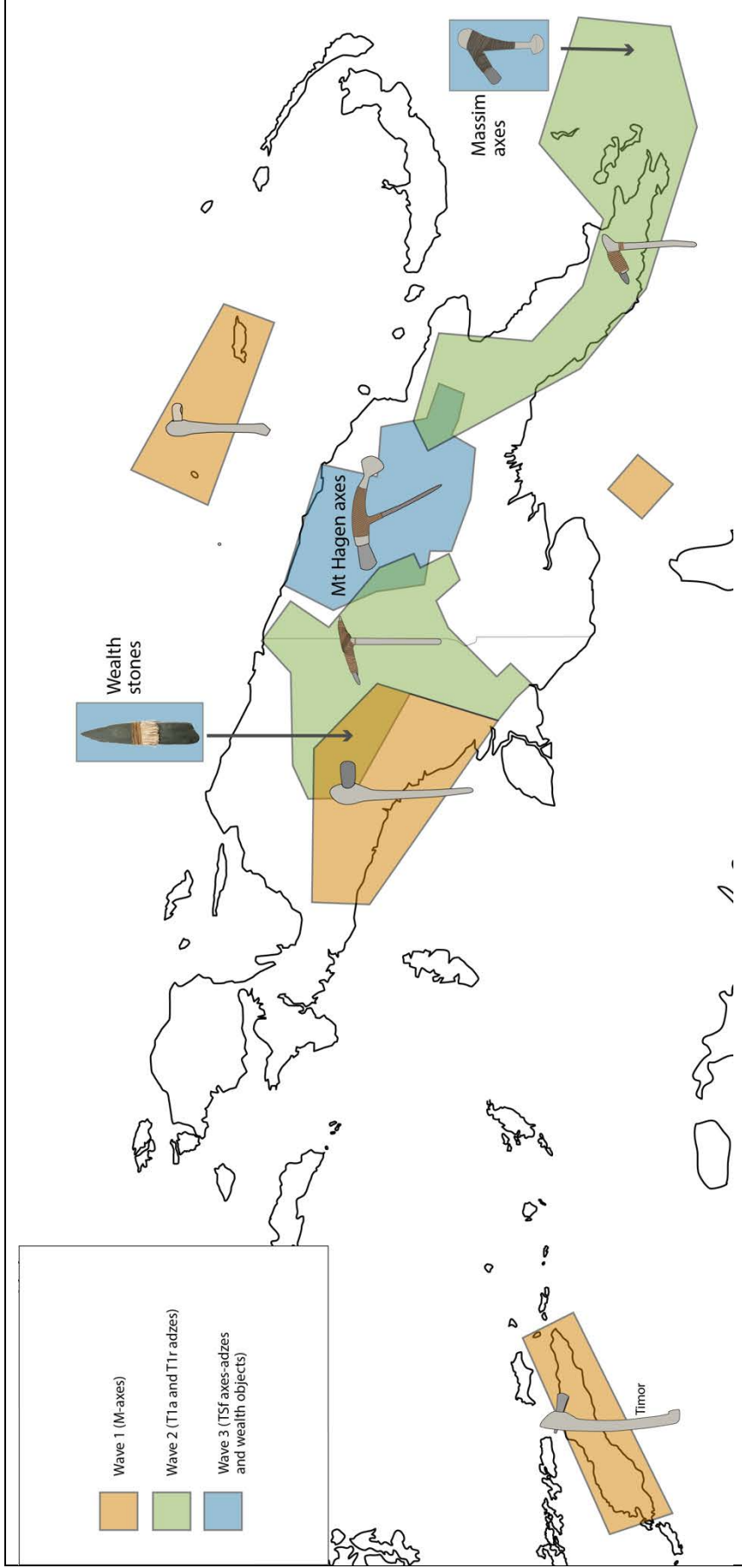


Fig 18. Three-wave model for the innovation and spread of stone tools in highland New Guinea.

Wave 1: M-axes

The first wave began between 9000 and 6000ya and was associated with the appearance of permanent settlements in the highlands, forest-clearance and low-intensity agriculture, probably originating in the Central Highland region. This wave was associated with the dispersal of lenticular blades hafted as M-axes, and TNG-language speaking peoples.

This wave spread along most of the cordillera and to the islands of Timor, Alor and Pantar. In this respect it is significant that the M-axe, which is otherwise rare in ISEA, was present on Timor, as an early photograph shows (Fig 19). The axe in the photograph was hafted with a metal blade that echoes the shape of stone blades, and the handle was similar to forms found in the southwestern province of Papua.

This wave spread widely in New Guinea, but only traces remain today in the form of M-axe usage in regions that are remote from the highland centers of innovation.

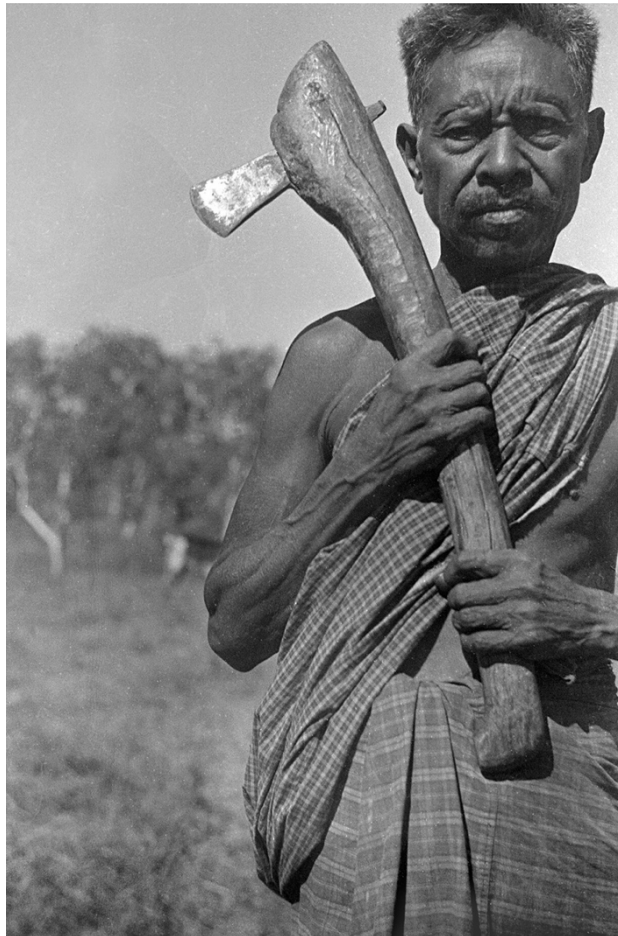


Fig 19. Tetum man with axe, Belu Regency, Timor. After Vroklage (1952: Pl VI). Captioned (in German): 'Typical domestic axe shape, reminiscent of a prehistoric axe'. CC0 1.0 Universal Public Domain Dedication.

Wave 2: T1a and T1r adzes

The second wave was associated with the intensification of agriculture and the spread of the adze, a superior tool for general woodworking and vegetation management that extended the life of valuable stone blades. Adze use was associated with two centers of innovation: T1a adzes in the west (centered on the Baliem Valley region), and T1r-adzes in the east (the Central Highlands).

Most of the tools in these regions persisted into recent times, except in the Central Highland region where T1r adzes were replaced by a third wave.

Wave 3: T1f axes and wealth stones

The third wave was associated with further intensification, probably associated with the arrival of the sweet potato during the last millennium. Increased carbohydrate production from this crop enabled the highland economies seen today, based around sweet potatoes and pig rearing. This created the conditions for population growth and the production and circulation of wealth goods, including stone valuables. Prestige TSf tools replaced older T1r adzes in the Central Highlands, and wealth stones were produced and circulated in the Baliem Valley and Massim regions.

Coastal regions

While these developments were taking place in the highlands, hafted tool use in coastal regions developed along different lines, focused on TS and MS forms suited to canoe making and sago exploitation (tree cutting tools and pounders). Relatively rapid communication by rivers and sea meant that technologies moved faster on the coast than in the interior, so links between language groups (eg Papuan vs Austronesian speakers) are harder to discern and the origins of these technologies (local vs imported) are harder to trace. From the widest perspective, the distribution of T1 adzes in the AP region, and the scatter of TS forms across the Pacific region suggests that some forms were re-invented multiple times.

3.7 Polynesia

This region was explored and settled by peoples speaking Austronesian languages (Lapita voyagers). The expansion of this group is thought to have originated in the Bismarck Archipelago, moving into Western Polynesia (Tonga, Samoa, Futuna) and the Fijian archipelago around 3000ya, with a second wave of sea voyaging that resulted in the settlement of the most remote islands around 1000-800ya.

Despite the complexity of hafted tools found in the Bismarck Archipelago, and evidence of contact and interchange between incoming and indigenous populations (Shaw et al 2022), a single tool type came to predominate in Polynesia. This was a distinctive variant of the T1 adze, mainly hafted with grey basalt blades. Blade cross-sections varied from circular-oval (Fiji) to square, triangular, or trapezoidal. Some blades have parallel edges and can be classified as quadrangular. Many have prominent tangs to aid hafting. Finish varied from rough flaking to

fine, precision grinding. The blades were generally hafted as T1-adzes, with the blade set behind a step in a wooden handle. There are few, if any, similar tools in the Bismarck Archipelago, which begs the question of how and where these forms developed.

Adzes are not common in Lapita archaeological sites, but a site in Tonga dating from 2700-2500ya, a relatively early phase in the settlement of Western Polynesia, yielded a variety of complete and fragmentary stone adzes. These adzes were mainly plano-convex forms lacking obvious tangs (Reepmeyer et al 2021). The assemblage is not obviously different from blades found in New Guinea (for example), implying that distinctive Polynesian forms developed after this primary colonization event.

An interesting group of adzes and adze blades were collected by early travelers from Polynesian-language speaking atolls north of the Solomon Islands. The adzes, classed as 'Northern Polynesian Outliers' by Crosby (1973b:54-60) vary greatly in finish and overall quality, but include some with Tridacna blades of exceptional workmanship, such as the one Crosby illustrates from Luanguia Atoll (Fig 6). Similarly well-shaped Tridacna blades were collected from the Micronesian Islands to the north of this region, such as Chuuk, Nukuoro and Pohnpei. These Tridacna blades are distinct from the more common lenticular shell blades that are found across much of Melanesia and Micronesia. Some blades have a triangular cross section, a profile that is also found amongst Polynesian basalt blades. The better-finished shell adzes seem to have been wealth objects rather than practical tools.⁶ Similar shell adzes were also found in Eastern Polynesia, such as an example from Tokelau in the Museum of New Zealand (accession number FE006244).

The Polynesian Outliers group was settled around 1000ya, at around the same time as Eastern Polynesia (Leppard et al 2022). There are close links between populations in the Polynesian Outliers and those in Eastern Polynesia, underlined by recent genetic work (Hudjashov et al 2018), and this final phase of expansion seems to have been characterized by continuing close links between the newly colonized regions via long-distance voyaging. The Polynesian Outlier adzes and the Tokelau adze raise the question of which came first, the shell adzes with their characteristic shapes, or the basalt group? One possibility is that distinctive Polynesian basalt blades copied earlier, prestige Tridacna blades.

During the last millennium, basalt and blades were exchanged between Polynesian islands, reflecting their special status and value. Studies of blade geochemistry in the Tuamoto archipelago (Collerson and Weisler 2007) and the Southern Cook Islands (Kirch and Kahn 2007, Weisler et al 2016) and Tonga (Clark et al 2014) have demonstrated that blades were traded over long distances in a network that linked the remote islands of the Pitcairn and Hawaii groups with the centrally located Tuamoto archipelago, Society Islands and Cook Islands (Fig 6).

⁶ An impressive white Tridacna blade in the Pitt-Rivers Museum from Pohnpei in the Caroline Islands has a hand-written inscription that reads: "Ki", excavated from the King's Tomb on Nan Tanach Island, Metalanim, by F.W. Christian. Purchased 1899. 1899.82.1

The study by Weisler and colleagues at the Tangatatau rockshelter on Mangaia Island (one of the southern Cook Islands) found a variety of blade shapes originating from a wide area, including imported stone from as far away as the Marquesas Islands, 2400km distant from Mangaia. This trade lasted from around 1000ya to around 400ya, which is presumably the period in which Polynesian adzes acquired their final forms and which explains the close similarities between tools from far-flung regions.

In addition to T1 adzes, TS tools (sleeved forms) are found in a few places, such as the Penrhyn Atoll and the Hawaiian Islands. Sleeving blades is an idea that might have been brought by early settlers or might have been invented independently in these places.

4. Convergent evolution in ground and hafted tools

hafted stone tools that have appeared independently in different parts of the world, a phenomenon that is well-illustrated by comparing ethnographic tools from the AP region with tools from the European Neolithic.

The importance of convergence on hafted tool forms was first suggested by Leroi-Gourhan, who referred to the 'inevitable and limited choices the environment offers to living matter' (1943:14) and went on to discuss the trend that 'propels the hand-held flint to acquire a handle' (1943:27). He called this 'evolutionary determinism' (*déterminisme évolutif*) and remarked upon the near universal distribution of hafted tools of generally similar types, used for woodworking, around the world.

The effects of convergence on ethnographic tools in the AP region has been remarked upon by a number of authors: Steensberg, in his comparison of present-day and prehistoric agricultural practices remarks on the similarity of M-axe hafting in New Guinea and prehistoric Europe (Steensberg 1980:18). Similarly, the Petrequins (2020:18, 1998) remark on the 'technological determinism' that explains 'the remarkable resemblance between these New Guinean simple axes and the felling axes of the Middle Neolithic II of Western Europe'.

As a definition of 'convergence' I will take the one proposed by Michael O'Brien and colleagues: 'Convergence is the phenomenon by which evolutionary processes result in the same, or similar, forms in independent lineages as a result of functional or developmental constraints' (O'Brien et al 2018:ix). This definition and the phenomenon it describes are familiar to biologists, who can identify numerous cases where unrelated (or distantly-related) biological lineages have generated similar solutions to basic physical problems, such as locomotion. It is probably just as important in material culture as in biology, however there are far fewer satisfying examples in material culture. This is mainly because of the difficulty of identifying truly independent developments in human culture, in which ideas are readily exchanged (in principle, at least) between unrelated individuals. The wide separation in time and distance between the AP region and the European Neolithic therefore offers the opportunity for some unique comparisons.

I begin with blade shapes, and then consider hafting styles.

Convergence in blade forms

The 'default' shape of a fully-ground stone blade, present in all regions of the world where such blades appeared, is a lenticular in cross-section; oval, or teardrop-shaped in plan-view. This is a consequence, in part, of the symmetry properties of the simplest whole-blade grinding procedure (bifacial grinding).

The most straightforward way to grind a blade is using a linear back-and-forth motion along the length of the blade, applying the grinding action alternately to two opposite faces to smooth the tool and form a cutting edge. This action wears a shallow concave groove in the grindstone, and a corresponding convex face appears on the ground tool. With two such faces, the tool acquires a lenticular cross-section. If the process is carried to completion the result will be a tool of oval or teardrop shape that is (in the limit of even grinding) virtually independent of the starting shapes of the tool and grinding surface. In practice, grinding is not evenly applied, for example additional ground surfaces such as bevels will be added near the cutting edge, but the tendency towards the lenticular-oval form can be observed in ground tools worldwide, including types that have arisen in different regions independently. Grinding can also be carried out on multiple faces, resulting in more complex cross-sections, such as convex-triangular or quadrangular.⁷

Some stone naturally cleaves into flat sheets or comes out of the quarry in tabular form. This type of stone is most efficiently shaped by sawing: cutting the stone using a cord and abrasive grit. This process can produce more complex tool shapes, particularly thin-profile or square-profile tools with four or more faces, which are subsequently refined by grinding to produce smooth, slightly convex faces.

Convergence in hafting styles

To investigate possible convergence in hafting methods in a systematic way I will compare tools from the AP region with hafted tools from the European Neolithic (EN). I list the types found in the EN, then compare the types from the two regions using a version of the morphospace outlined above.

Most archaeological discoveries of tools in Europe are unhafted, but a remarkable series of hafts have been preserved in waterlogged sites at lakeside dwellings in Europe. The oldest known hafts come from La Draga in Spain (Palomo et al 2013), from around 7000ya. Small to medium-sized stone blades were hafted as adzes on wooden handles, with the blade lashed to the top and secured behind a small 'step'. Blades and handles were found separately, suggesting that they were assembled when needed. A more extensive series of hafted tools comes from lake sites in Switzerland and France, described by Stöckli et al (1995), Suter (1981),

⁷ The symmetry properties of random grinding processes can be exploited to produce extremely accurate curved surfaces. For example, in optical work, a lens or mirror surface with precise spherical geometry can be produced by applying random grinding motions to two flat glass discs with an abrasive grit in between.

Petrequin and Petrequin (1998), and Beugnier and Maigrot (2005). Forms include both axes and adzes.

Some axe blades were hafted directly into a hole in a wooden handle using a mortise-and-tenon arrangement (M-axe). This kind of neolithic axe seems to have been widespread type in northern Europe, examples having been found in England and Sweden, as well as alpine lake dwellings. Some axes had straight handles while other types had bulbous heads, which presumably increased the strength and durability of the axe head. There is a continuum between 'straight' and 'bulbous' axe forms. Some EN axes have bulbous heads with a slight backwards slope, a tendency that is also seen in some ethnographic axes from southern New Guinea. This is presumably a design feature that was arrived at independently in both locations, to reduce the chances of the haft hitting the working surface.

Other blades were attached directly to the top of a wooden haft (T1). Most of these blades seem to have been oriented as adzes, as in the AP region.

Some blades were set into a bifurcation in the bend of the haft (T1b-axe or T1b-adze). Both of these arrangements are also found in ethnographic tools made on New Guinea.

Other tools were made by first embedding the blade in a sleeve of deer antler, analogous to AP forms with sleeves made of wood, and presumably made for the same reasons. The sleeved blade could then be mounted mortise-and-tenon fashion, oriented either as an axe or an adze (MS-axe, MS-adze). Both varieties have been found in the Swiss Jura from around 6000ya. Other sleeved blades were lashed to the top of a T-shaped or L-shaped haft (TS). A type that is occasionally encountered in the EN consists of a sleeve of deer antler fitted over the top of the toe of a T or L-shaped haft (TSv). No exact parallel of this type has been found in the AP region. It depends for its construction on the strength of deer horn and the presence of a natural channel in the center, features that would be difficult to reproduce in a wooden sleeve, which would tend to split if hafted this way.

In both the EN and AP region, hafts were made from a tree branch and portion of a tree-trunk, exploiting the natural angled form with its inherent strength. In both regions resinous materials (tree resin, bitumen) were sometimes used as an aid for attaching blades more securely to handles.

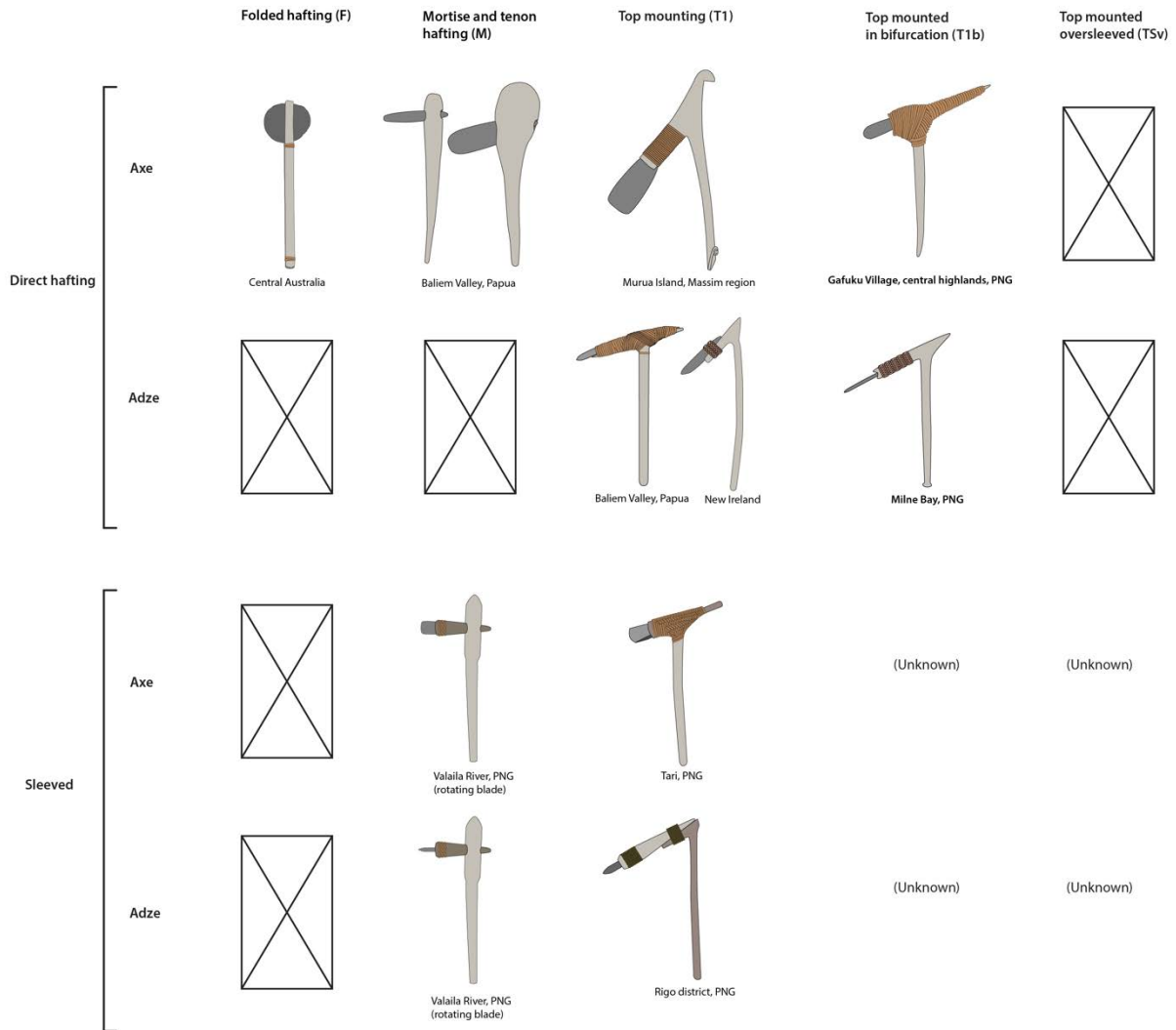
As with AP tools, EN hafted stone tools seem to have been used for woodworking, for which there is archaeological evidence in the form of shaped wooden planks and piles.

Morphospace-based comparison of hafting methods

Accommodating the additional variations in hafting methods T1b and TSv gives a morphospace with 14 theoretically possible tool types. Mapping actual forms onto this morphospace (Fig 20) shows that 10 of these forms were found in the AP region, and 8-10 in the EN (the range reflecting the unknown blade orientations of some archaeological tools). Of these, seven types were found both regions. In other words, nearly all of the hafting methods used in the EN were

independently discovered in the AP region. This is a striking confirmation of Leroi-Gourhan's observation that tool forms and hafting methods are governed by the fundamental constraints and affordances of wood, stone, fiber, and the human physique.

Asia-Pacific:



European Neolithic:

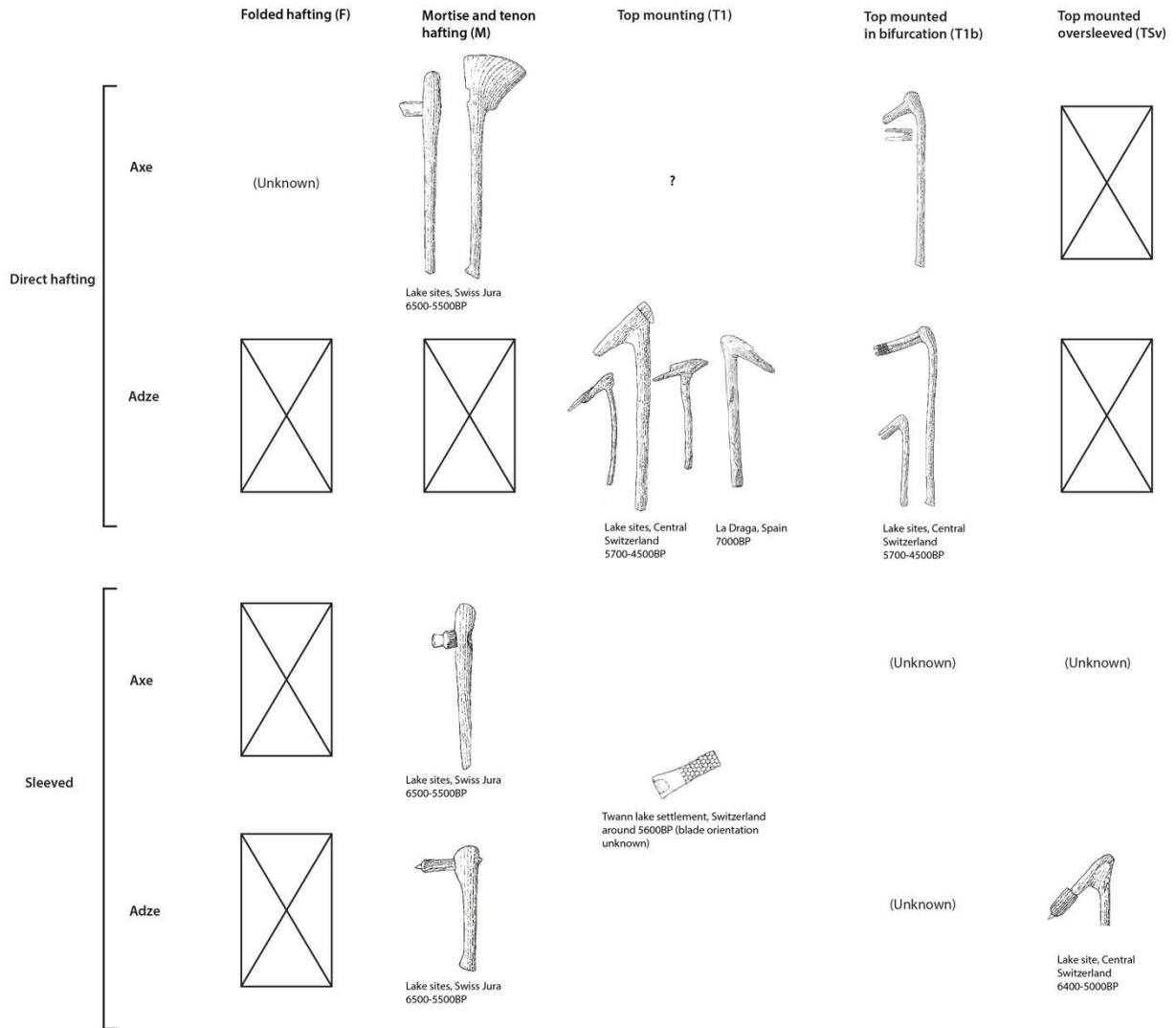


Fig 20. Comparison of ethnographic hafted tools from the Asia-Pacific region (above), with archaeological hafted tools from the European Neolithic (below). Drawings of European Neolithic tools after Stöckli et al (1995), Suter (1991), and Palomo et al (2013). Forms that are impractical are marked with boxes.

As noted, the archaeological contexts of EN tools imply that they were used in the same ways as ethnographic tools from the AP region: forest clearance and vegetation management associated with agriculture, and woodworking (including the construction of fences and houses). The main differences between the EN and AP tools relate to raw materials. In the EN there was a preponderance of tools with blades fitted into deer horn sleeves. This material is absent in NG, where wood is used for the same purpose and the range of sleeved types is more limited. Deer horn is a near-ideal sleeving material, tough and resistant to breakage, with a hollow core that accepts stone blades readily. Sleeving provides major advantages for the tool

maker: it reduces the risk of breaking the blade, and it enables smaller blades to be used. This extends the useful life of stone blades by allowing them to be used until they are worn down to a few centimeters in length. Stöckli et al (1995) suggest that the use of sleeves in hafting stone tools in the EN was limited only by the availability of deer horn.

Stockli and co-workers provide a chronology of types at Neolithic lake-dwellings, noting that in any given location at any given time only one or two types were in use. Petrequin and Petrequin (1988: 260-261) suggest that tool forms were culturally specific, since it is otherwise difficult to explain the use of the adze by some European groups but not others.

The parallels between the EN and NG are not limited to functional tools. In both regions, ground and polished greenstone blades were also traded as wealth and prestige objects. In the Baliem Valley in New Guinea, large, polished stones were kept for exclusive use as wealth objects, for bride-price exchanges and formal gifts. As described above, in the Lake Sentani region of New Guinea, polished greenstone blades were made for the sole purpose of wealth accumulation and bride-price exchanges. The Sentani blades are remarkably similar in appearance to polished greenstone and jade tools that were circulated widely in Europe during the neolithic period. Such blades had perfectly symmetrical forms with no traces of use-wear or hafting polish: in the EN they were associated with high-status burials.

The conclusion is that similar tools in the European Neolithic and the New Guinea were developed independently by peoples with similar needs for vegetation management, woodworking, and prestige goods: a remarkable example of convergent evolution in material culture.

5. Correlations between material culture and language: questions of scale and data

The issue of the extent to which different aspects of culture are correlated (evolve together or evolve separately) is a long-standing one. In the case of New Guinea, a dataset based on museum examples of material culture sparked a controversy concerning the presence or absence of such correlations. The items in question were collected by Albert B. Lewis on behalf of the Field Museum of Natural History, during an expedition sponsored by the Museum from 1909-13. Lewis, in common with most early visitors, traveled by boat and collected items from coastal communities. The items he assembled include a wide variety of everyday objects such as headnets, spoons, and bows and arrows. The communities that he visited on the north coast of Papua included speakers of Austronesian and Papuan languages.

After a gap of 90 years, this collection was surveyed and analysed systematically by Welsch, Terrell and Nadolski (1992), who assembled a dataset comparing geographic locations and language with material culture. They concluded that the material culture of these coastal villages correlated mainly with how close they were to each other, rather than the languages they spoke. The data was re-analysed by Moore and Romney (1994), and later by Shennan and Collard, both of whom argued that Welsch and colleagues were wrong, and that correlations exist between language and material culture as well as geographic distance.

My purpose is not to re-open the debate over the analysis of this dataset, but to ask a simpler question: why are correspondences between material culture and ethnicity so difficult to discern (requiring cutting-edge statistical analysis) in the Lewis dataset?

This book highlights striking correspondences between material culture (hafted stone tools) and language that are apparent 'by inspection'. At a local level in the Baliem Valley (Chapter xx), Wola people used only large M-axes, whereas their neighbors, the Dani, used a T1a-adze hafted with a lenticular or planilateral blade for most of their daily needs, using M-axes only for splitting firewood. Further to the east, the Yali people used only adzes, but these were of a different shape to Dani adzes, and the blades were convex-triangular in cross-section. All of these peoples lived in substantially similar environments, growing similar crops. All were familiar with their neighbors' tools, but none showed any inclination to copy them. The boundaries between these cultural zones were sharp and clearly defined: a visitor to the Valley could tell where he or she was by looking at the tools in use in the fields. A similar story was repeated in every part of the highland region.

Zooming out and looking at the question at the largest scale, relationships between the tools used on Pacific Islands and the languages and cultural histories of their users are readily apparent. In Remote Oceania a closely related group of Austronesian languages are spoken, and a narrow range of T1 and TS-adzes were used in daily life. In the highland region of New Guinea, different tools are used by speakers of different TNG languages in well-defined regions, which, as described, relate to the complex cultural history of this linguistic family and the development of farming.

I offer three thoughts on this topic. The first relates to the data itself. Collecting 'traditional' tools for the Field Museum posed a problem for Lewis, since steel tools (for example) had already replaced stone blades in all but one of the coastal locations that he visited. In his collecting Lewis 'eschewed objects that illustrated the acculturative process in favor of "traditional" things' (Welsch 1998:7). In the case of axes and adzes the presence/absence data is probably telling us more about Lewis's success or failure to obtain 'traditional' items. The dataset also lumps all such tools together into a single category of 'axes/adzes', obscuring the distinctions that this review has shown to be key. Similar questions could be asked of other items in the survey. Clubs ... what kind? Loincloths ... woven, plaited or bark-cloth? Pottery ... coiled or paddle-beaten?

The second thought relates to the differences between the coastal regions that Lewis visited and the interior. The inhabitants of the coast were almost invariably involved in trade. This included local trade, some of which was practical and some of which was social in nature, such as the Kula ring described by Malinowski, as well as long-distance trade with Chinese and other sailing vessels. This trade was not a new thing, it had been going on for thousands of years, as the presence of Dong Son bronze objects in coastal areas of New Guinea attests. This does not mean that distinctions between coastal communities did not exist, they certainly did, as Lewis's

diaries of his voyages describe. However, a faster exchange of goods (and ideas?) was possible than in the interior, where relations between neighboring groups were often hostile.

The third thought relates to the question of scale. As discussed, correlations between material culture and language are easiest to discern at the smallest, local scale and also at the largest, regional scale. At the largest scale there is little or no direct interaction between communities because they are isolated by distance. **This lack of interaction** leads to distinctions that gradually increase, through the forces of invention and cultural drift, and persist over millennia.

It is at intermediate scales, like the one that Welsch and colleagues investigated, that the question becomes a more subtle one. Communities that are not adjacent or in daily contact may still exchange information through trade and occasional contact, and a valuable idea could cross community boundaries through its intrinsic appeal. Despite huge differences in language, rather similar net bags, made by a knotless looping process and worn on the head, are present in nearly all parts of New Guinea, from the coasts to the highlands. The force of convergent evolution, as discussed in relation to stone tools, limits differences in cases where a limited number of technological options are available. These tendencies towards material cultural convergence are opposed by countervailing forces of cultural drift and invention/elaboration, which tend to drive differences between communities. Where this balance nets out between these forces depends on the mix of local circumstances and cultural histories.

Final remarks

The distribution of material culture has not been a popular or significant research topic since the early part of the 20th century. This is a pity, since there is much to be gained from this work (as I hope this review demonstrates).

A key point that emerges is that scale of observation is crucial: New Guinea material culture shows clear differentiation at the community level, a complex tangle at intermediate scales, and clear differentiation once more at the largest regional scales.

The contrast between language diversity and material culture diversity is also interesting. New Guinea languages are reckoned to be exceedingly diverse, to the point where many are apparently unrelated. Daily-use tools across the island (such as adzes and net bags) also take many different forms, but these forms have obvious relationships. Why so? The features of languages that linguists are mainly interested in (combinations of sounds that make up cognate forms) are, for all intents and purposes, unconstrained. The consequence of this is that languages can diverge to the point where there is no apparent connection between cognate forms. Grammar can also diverge, but in this case the feasible options are more limited. Aspects of basic tools, on the other hand, are severely constrained by physics and physique, as the comparison of New Guinea tools with those of the European Neolithic shows. Diversity in material culture exists, but it is found at a different level, for example in the details adze binding systems and details of blade shape, which are specific to individual cultures.

Ground, polished and hafted stone tools are linked to lifeways, cultural histories and social exchanges, as well as general questions about how material culture evolves and the forces that shape it. Their types and distributions have interesting things to say about all of these topics.

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