

Early Agriculture in the Highlands of New Guinea: An Assessment of Phase 1 at Kuk Swamp

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ABSTRACT. The wetland archaeological evidence for Phase 1 at Kuk Swamp, Wahgi Valley, Papua New Guinea, is evaluated in terms of previous interpretations of the artificiality and agricultural function of the palaeochannel and palaeosurface. The evaluation concludes that the current evidence is insufficient to warrant claims of artificiality for the palaeochannel and some palaeosurface elements. Drawing on previous multi-stranded arguments proposed by Jack Golson and Philip Hughes, new lines of multi-disciplinary evidence suggest a revised interpretation of the wetland archaeological evidence for Phase 1 at Kuk does not negate a long-term trajectory towards agriculture in the highlands of New Guinea from the Early Holocene.

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Agriculture in the highlands: an old concern

The development and antiquity of agriculture in the highlands of New Guinea, particularly its antiquity, have been continual concerns since the first archaeological excavations in the region. Bulmer sought to elicit signatures of a transition to agriculture from the lithic assemblages collected during her excavations at Yuku and Kiowa rock shelters in 1959–1960 (Bulmer, 1964, 1966). She suggested that “the direct proof of agriculture must depend on pollen analysis, on the future fortunes of archaeology in obtaining organic remains, and on the analysis and dating of ditches and drains of agricultural derivation” (Bulmer, 1966: 152).

In this paper, multiple forms of evidence claimed to indicate the presence of agriculture in the highlands of New Guinea at approximately 9,000 radiocarbon years before present (B.P.) are assessed. The main focus of the paper is a presentation of the wetland archaeological evidence for

Phase 1 at Kuk Swamp, the only site for which agriculture at 9,000 B.P. has been claimed (Golson, 1977, 1989, 1991; Golson & Hughes, 1980; Hope & Golson, 1995: 824). Although the specific interpretations have changed through time, it has been consistently argued that wetland agricultural practices were conducted as part of a broader land use strategy that included dryland environments within the catchment (Bayliss-Smith, 1996: 509). The evolution of these interpretations will not be reviewed here because the aim of this paper is to interrogate the evidence upon which they have been based.

The interpretation of agricultural activities at Kuk at 9,000 B.P. has always been controversial. Golson originally viewed the artificiality of the evidence for Phase 1 with scepticism and uncertainty (Golson, 1977: 613–614). Since then, he has referred to the agricultural interpretation of Phase 1 as “indirect and unusual” (Golson, 1982: 56), “possible” (Golson, 1991: 484) and as being based on

analogies with more recent prehistoric evidence (Golson, 1991: 485; Hope & Golson, 1995: 824). In recent years, the nature and significance of the early phases at Kuk, particularly Phase 1, have been called into question within the broader archaeological community (e.g., Spriggs, 1996: 528). Indeed, some reviews of the global origins of agriculture question whether New Guinea was an independent centre due to the equivocal nature of the early evidence at Kuk (e.g., Smith, 1998: 142–143).

The wetland archaeological evidence for Phase 1 at Kuk, together with evaluations of its artificiality and agricultural function are presented in the first half of the paper. However, Golson, both individually and with Hughes, has drawn on a wide range of evidence to support a claim of agriculture at 9,000 B.P. (Golson, 1977, 1991; Golson & Hughes, 1980). In the second half of this paper, and in accordance with Golson's multi-stranded approach, a range of new evidence and ideas with a bearing on agricultural origins in New Guinea is briefly reviewed. This review concludes with a re-evaluation of the idea of agricultural origins at 9,000 B.P. in the New Guinea highlands.

Phase 1 at Kuk: the evidence

Golson and co-workers intensively investigated Kuk Swamp in the 1970s and 1980s, with additional fieldwork being undertaken in 1998 and 1999 by Denham and Golson. In

total, over 200 trenches were excavated, and archaeological and stratigraphic recording occurred along approximately 10 km of modern plantation drain (Fig. 1). From the thousands of features, mostly prehistoric field drains and house sites, Golson identified six major periods of prehistoric agricultural drainage (Table 1).

The archaeological evidence for Phase 1 was exposed in relatively few trenches and plantation drains (Fig. 2). The majority of trenches were designed to investigate more recent drainage phases, and did not penetrate down sufficiently to expose the older stratigraphy. The evidence for Phase 1 was located in the southeastern portion of the plantation, close to a former margin of the wetland. Test excavations located to the north did not detect any artificial features beneath the grey clay or equivalent stratigraphic unit.

Table 1. Prehistoric agricultural phases at Kuk Swamp (Golson, 1982). All ages given in uncalibrated radiocarbon years.

phase	age (B.P.)
6	250–100
5	400–250
4	2,000–1,200
3	4,000–2,500
2	6,000–5,500
1	c. 9,000



Fig. 1. Location map depicting excavations at Kuk.

The evidence for Phase 1 at Kuk Swamp has two main inter-related components, a major palaeochannel and a palaeosurface comprised of inter-cut features. The pre-grey clay palaeosurface was inferred to be “chronologically and perhaps functionally associated” (Golson, 1982: 56) with the palaeochannel. The evidence and possible interpretations of each major component are described below.

Stratigraphically, the palaeochannel and palaeosurface were filled and sealed by a massively structured grey clay. The grey clay was a component of a fan emerging from the low-lying hills and drainage basin to the south of the wetland. Similar deposits, superimposed on Pleistocene fans, extended south onto the northern margins of the wetland from a ridge to the north (Ep Ridge). The grey clay has been interpreted to represent accelerated erosion (Hughes, 1985; Hughes *et al.*, 1991), which was a product of agricultural clearing for swidden-type, dryland cultivation (Golson, 1991: 485). It has been presumed that deposition of this fan commenced with the abandonment of the short-lived Phase 1 palaeochannel, which occurred at c. 9,000 B.P.; formerly the palaeochannel had transported sediments away from the swamp margin.

The palaeochannel

The major palaeochannel was traced in excavation trenches and plantation drain walls across the southeast portion of the plantation (Fig. 2). The field evidence suggested that it flowed northeast across the wetland margin, that it was relatively wide and shallow and that it dated to approximately 9,000 B.P. (Golson & Hughes, 1980). The palaeochannel was presumed to have been dug in order to divert drainage waters from the southern catchment away from the swamp margin, thereby enabling cultivation of adjacent surfaces (Golson, 1977: 614; Golson & Hughes, 1980: 298). Four aspects of the palaeochannel have been proposed as indicators of its artificiality: straightness of course, passage through elevated areas, morphology, and its temporal occurrence and duration (Golson, 1991: 484; J. Golson & P.J. Hughes, pers. comm.). Each aspect is discussed in detail below.

Firstly, the straightness of the palaeochannel’s course between marked curvatures was suggested as an indicator of its artificiality through analogy with the major palaeochannels of later phases (Golson, 1991: 484). In a

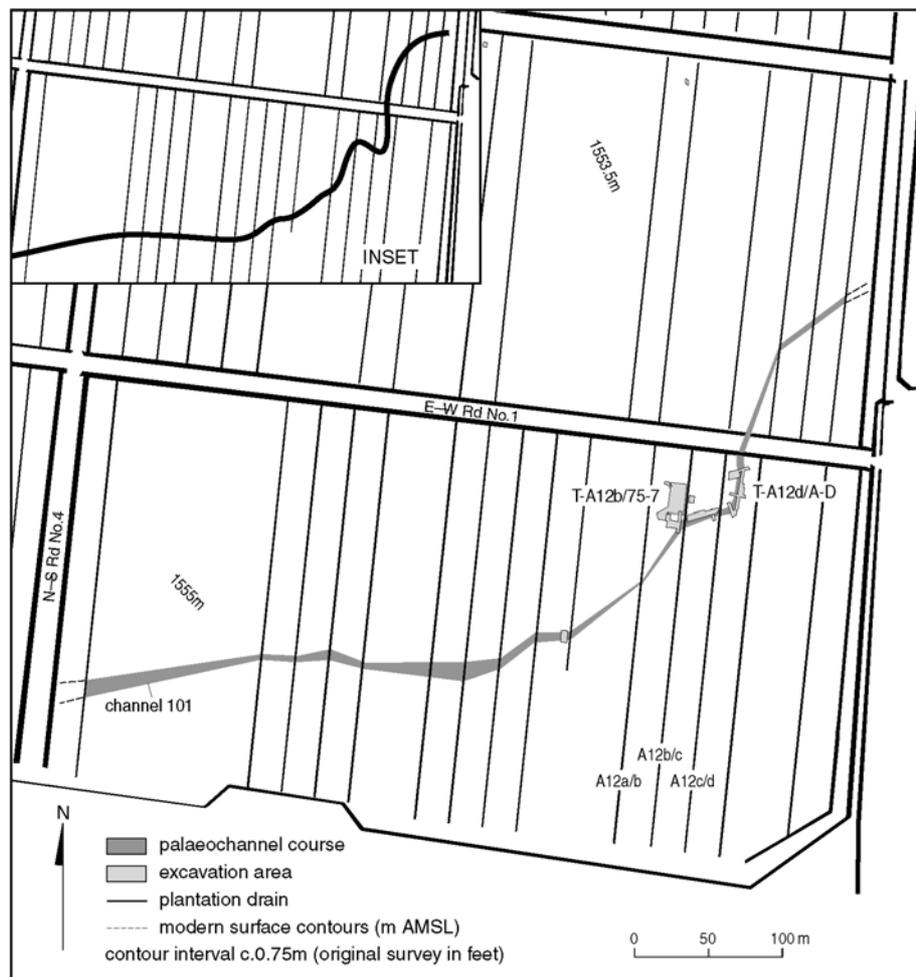


Fig. 2. Map of palaeochannel course relative to Phase 1 excavations (e.g., T-A12b/75–77) and plantation drains (e.g., drain A12a/b) with inset of previous course depiction (latter based on P.J. Hughes plan).

previous reconstruction, undertaken while fieldwork was ongoing, the course of the palaeochannel was not entirely straight and changed direction markedly in at least two locations (Golson, 1977: 615; Fig. 2 inset). The straight sections of the palaeochannel were considered unlikely to have formed naturally across this low gradient swamp margin.

Replotting of the palaeochannel's course, based on the excavation trenches and plantation drains in which it was exposed, clearly shows that straight sections are solely a product of interpolation between known points (Fig. 2). Those sections of the palaeochannel's course for which there are closely spaced records all exhibit slight sinuosity. Such sinuosity is expected across a low gradient slope. Furthermore, the one location in which there is a marked change in direction had higher constraining stratigraphy (see below). In general, the palaeochannel course was oriented to the northeast and perpendicular to the greatest angle of slope.

Secondly, the artificiality of the palaeochannel was inferred from its passage through slightly elevated mounds of underlying Pleistocene ash substrate in blocks A12b, A12c and A12d. If natural, the palaeochannel would be expected to follow the path of least resistance to lower ground, i.e., it would be expected to follow the slope. If artificial, the course of the palaeochannel need not have been determined solely by topography. The latter scenario

was adopted by the original excavators based on the apparent passage of the palaeochannel through a locally elevated mound (implied in Golson, 1991: 484).

Based on a reconstruction of the Phase 1 palaeosurface topography and an examination of associated stratigraphic sections, the palaeochannel did not cut through significantly elevated ground. The area of greatest interest includes blocks A12b, A12c and A12d (Fig. 3). Between drains A12a/b and A12b/c, the palaeochannel flowed down slope and undertook a gradual change in course from northeasterly to east-northeasterly. Between drains A12b/c and A12c/d only a slight rise in pre-grey clay palaeosurface topography of <20 cm can be inferred (Fig. 4). In this comparison of palaeosurface heights adjacent to palaeochannel banks, only the northern bank in drain A12c/d has been considered because the southern bank had evidence of slumping and had undercut higher ground on the outside of this bend (Fig. 4b). The palaeochannel underwent a marked change in course in block A12d from east-northeasterly to northerly. These micro-topographic variations are not significant for three reasons:

1 Micro-topographic variations of such magnitude occur along the banks of small streams and are not necessarily determinate for channel course.

2 The alluvial stratigraphy in the vicinity of the palaeochannel is likely to be compactional. The higher areas

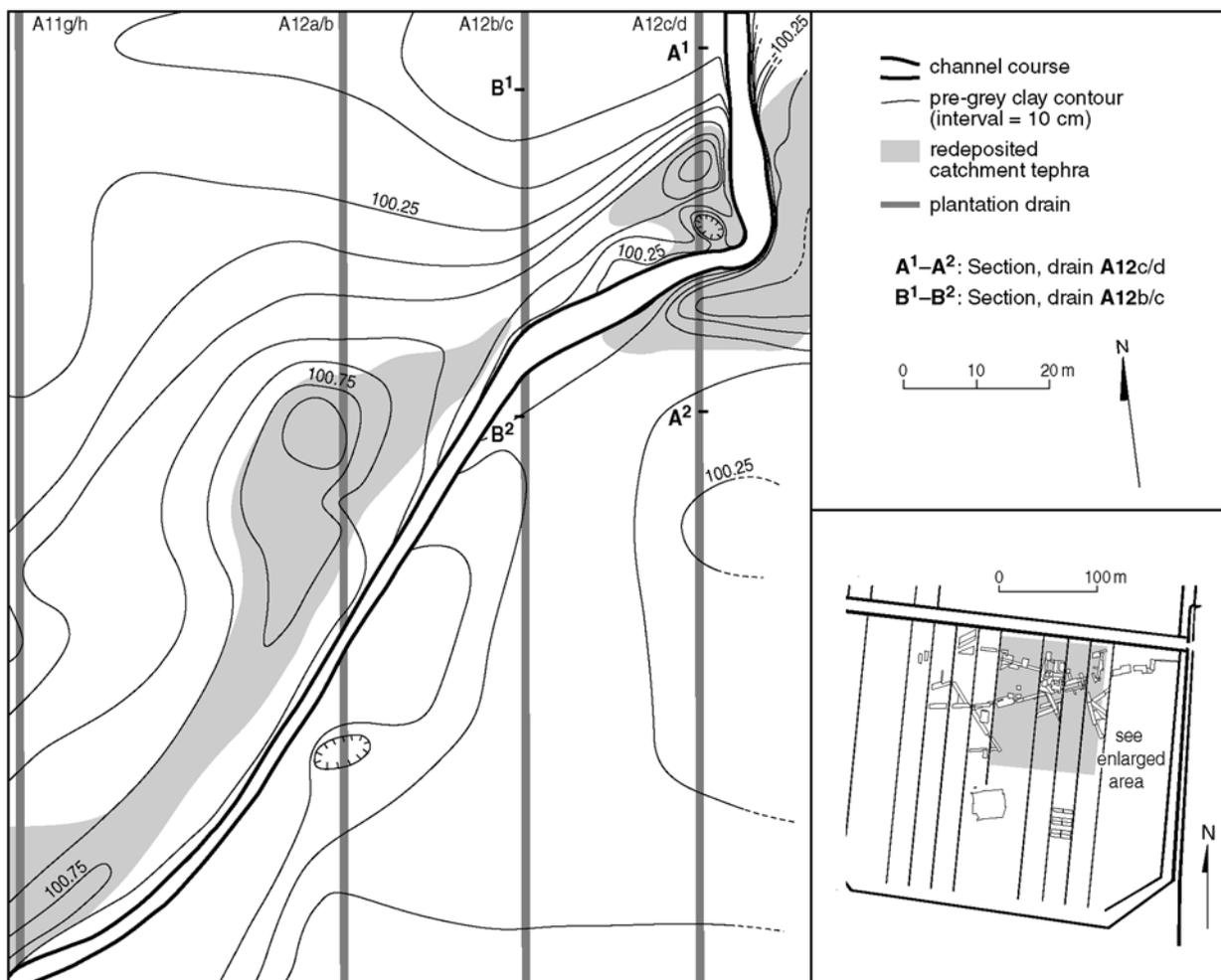


Fig. 3. Plan of palaeochannel course across pre-grey clay palaeosurface, with redeposited catchment tephra depicted (reconstructed by T. Denham from P.J. Hughes field notes).

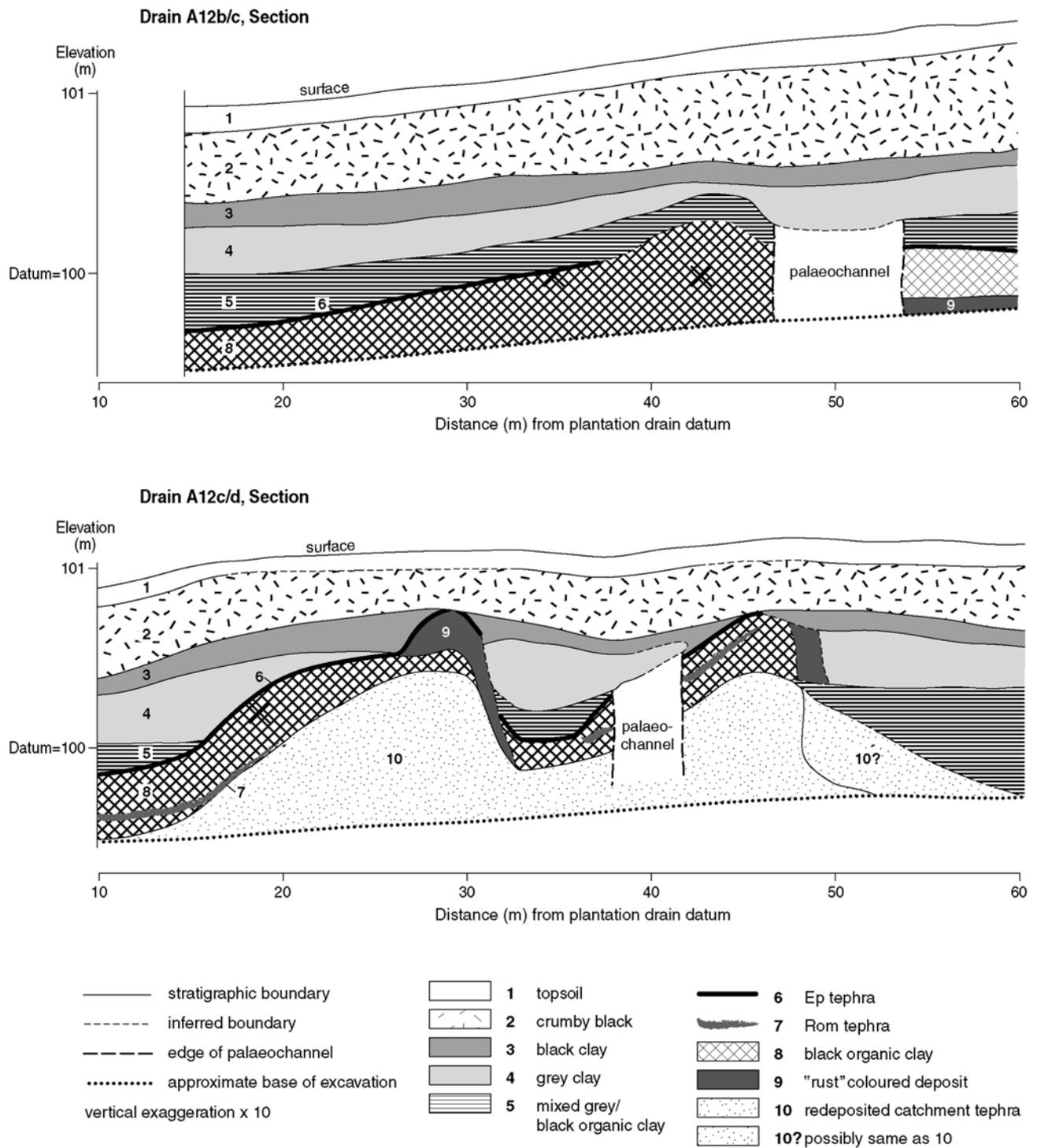


Fig. 4. Sections of drains A12b/c (Fig. 4a) and A12c/d (Fig. 4b), depicting palaeochannel course relative to stratigraphy (reconstructed by T. Denham from P.J. Hughes field notes).

of pre-grey clay palaeosurface are comprised of inorganic sediments, probably redeposited Tomba Tephra from the southern catchment. These areas appear to be higher than adjacent stratigraphy of the same age, but this is largely a product of post-depositional compaction associated with the differential ripening, shrinkage and wasting of more organic sediments away from the palaeochannel. Much, and potentially all, of the variation in relative height between more organic and inorganic sediments in the stratigraphy did not exist at the time of palaeochannel formation.

3 The redeposited catchment tephra forms a linear deposit that was subsequently followed by the palaeochannel (Fig. 3). In the drain A12c/d section, the relationship between the linear deposit and palaeochannel is clear (Fig. 4b). The palaeochannel cuts two Pleistocene tephra (Ep and Rom), which line an apparent depression between higher areas of redeposited tephra. Thus, and even if the "mounds" of redeposited tephra were apparent at the time of formation and were not a product of post-depositional compaction (which is unlikely), the palaeochannel followed

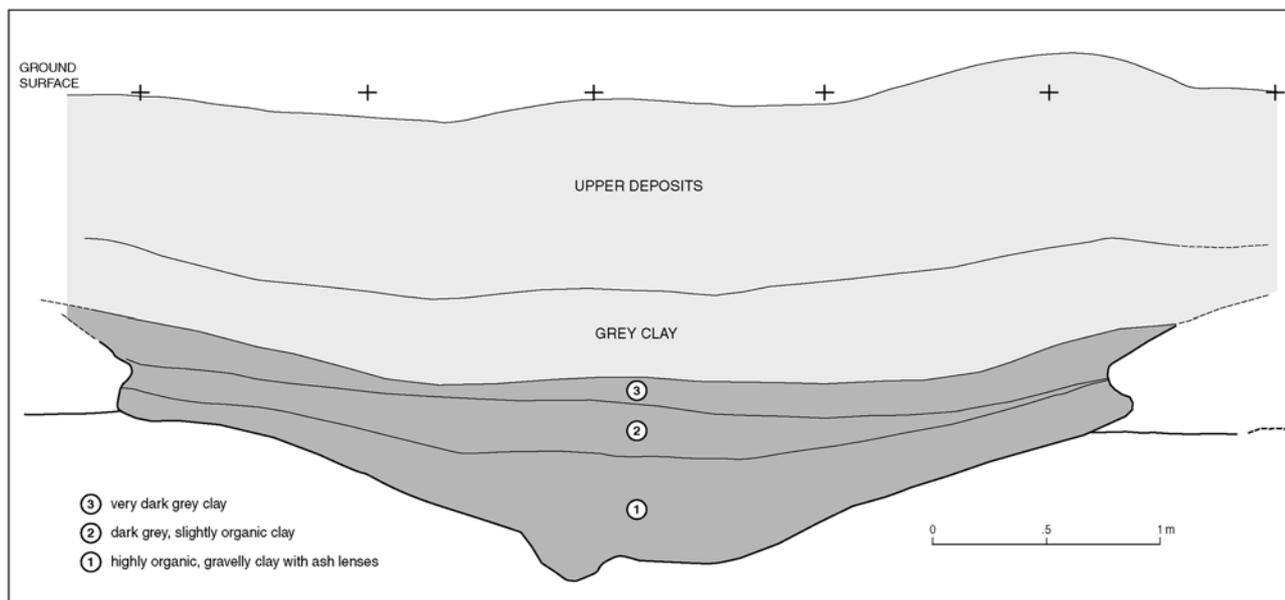


Fig. 5. Section of palaeochannel, S. face, N. drain, E-W Rd. No. 1. (reconstructed by T. Denham from P.J. Hughes field notes).



Fig. 6. Photograph along excavated palaeochannel bed, Trench A12d/C, view to south (taken by J. Golson).

an earlier Pleistocene depression that potentially constrained and deflected its course in block A12d. The most plausible explanation for the stratigraphy in this area is that the Early Holocene palaeochannel followed the course of an earlier, Pleistocene palaeochannel (see below).

Thirdly, the form of the palaeochannel in section and plan was investigated to determine if the morphology of the bed and banks could elicit its mode of formation. In section, the palaeochannel was wide and shallow, with gently sloping sides and a slightly rounded base (Figs. 5, 6). The upper portions of the banks appeared to be undercut, a product of fluvial erosion or mass movement processes during use or post-depositionally. The preserved form of the palaeochannel suggested that it was previously much narrower and had widened with time. Lateral erosion occurred along the banks, thereby making the interpretation of palaeochannel course based on adjacent palaeosurface elevations problematic (see above).

The recorded sections and trenches depict a wide and shallow palaeochannel with gently sloping sides (in section) and curved edges (in plan), respectively. These character-

istics could have developed in an initially steep-sided (in section) and straight edged (in plan) channel, which had been subject to scouring and slumping. Evidence for these processes was widespread. Given that these processes would be characteristic of both natural and artificial palaeochannels, it is not possible to discern mode of formation from palaeochannel morphology.

Fourthly and from a broader perspective, the temporal occurrence and duration of the palaeochannel have been suggested to be significant indicators of its artificiality. The fill sequence consisted of a basal organic deposit sealed by a series of very dark grey clays. The basal organic deposit consisted of a well-preserved admixture of leaves, wood, seeds, ashes and soil crumbs. The overlying massive, very dark to dark-grey clays were variants of the major grey clay depositional unit. Based on the depositional sequence, Golson and Hughes inferred this palaeochannel to have been short-lived (1980: 298). There was no other evidence of palaeochannels draining the southern catchment during the preceding 10,000 years and the following 3,000 years. Thus, the presence of an apparently short-lived palaeochannel at 9,000 B.P. required explanation and suggested anthropogenesis.

In contrast to Golson and Hughes' previous interpretations, the Early Holocene palaeochannel followed the course of a Pleistocene predecessor. An extremely stable palaeochannel course through highly organic stratigraphy may have existed from the Pleistocene to Early Holocene, at which time it was abandoned due to changes in catchment hydrology and sediment input. Similar "stable-bed and aggrading-banks" models have been proposed to account for the stability of palaeochannel courses in lowland Britain during the Holocene (after Brown, 1997: 24–25). In such situations, there is a tendency to underestimate the age and duration of a palaeochannel based on the fills that correspond to its last phase of use, as opposed to its broader stratigraphic associations. A similar scenario may account for the apparent absence of a palaeochannel during grey clay deposition; a palaeochannel may have been present

but it has been allocated to a later phase on the basis of radiocarbon dates of its fills.

In conclusion, no element of the palaeochannel's course or morphology suggests that it is "undeniably artificial" (Hope & Golson, 1995: 824). Rather, all elements are consistent with a palaeochannel flowing northeasterly in accordance with the general direction of slope. The slightly sinuous palaeochannel underwent a major variation in course in blocks A12d where it followed the course of an earlier palaeochannel.

The palaeosurface

The features exposed on the palaeosurface adjacent to the palaeochannel have been variously described (Golson, 1977, 1991; Golson & Hughes, 1980). Essentially they consisted of rounded and relatively shallow depressions occurring as either isolated features or inter-cut complexes. There were recurrent feature types, as some of the more defined and deeper depressions were associated with stake holes. Additionally, a number of stone artefacts were collected from feature fills or from the palaeosurface itself. Interpretations of these features as artificial and as evidence of agriculture have been largely based on their purported human origins (Golson & Hughes, 1980: 299) and the inferred chronological and functional associations between the palaeochannel and palaeosurface (Golson, 1982: 56, 1991: 484). Given that the artificiality of the palaeochannel has not been demonstrated, this may have major consequences for the interpretation of the palaeosurface.

Of the trenches excavated with the intention of exposing the palaeosurface, most contained only a few or no features. The only extensive palaeosurface was exposed in block A12b during successive investigations in 1975, 1976 and 1977 (Figs. 7, 8). For ease of description, the features have been grouped into complexes. These complexes each contain multiple micro-topographical, palaeosurface features. Across the exposed palaeosurface between these main complexes were numerous dispersed and discrete depressions.

Three composite, curvilinear or sinuous runnels (A, B and C) were exposed. These were multi-component complexes comprised of deeper basins connected by shallower depressions to form an irregular sinuous or curvilinear feature. Given their linear form, these features

have been interpreted as surficial drainage ways. Two complexes comprised of upraised areas defined by surrounding inter-cut depressions (D and E) were exposed. These two complexes were interpreted to have functioned in a similar way to the Phase 2 palaeosurface, i.e., the upraised areas were used for planting water-intolerant crops. These two complexes, however, were neither as integrated nor as regular as their supposed Phase 2 equivalents (as indicated by Golson, 1977; Golson & Hughes, 1980).

The artificiality of the palaeosurface is not self-evident. Although some of the deeper and more defined features appear to have been dug, it is equally plausible on morphological grounds that some represent natural micro-relief. Regular and irregular micro-relief has been

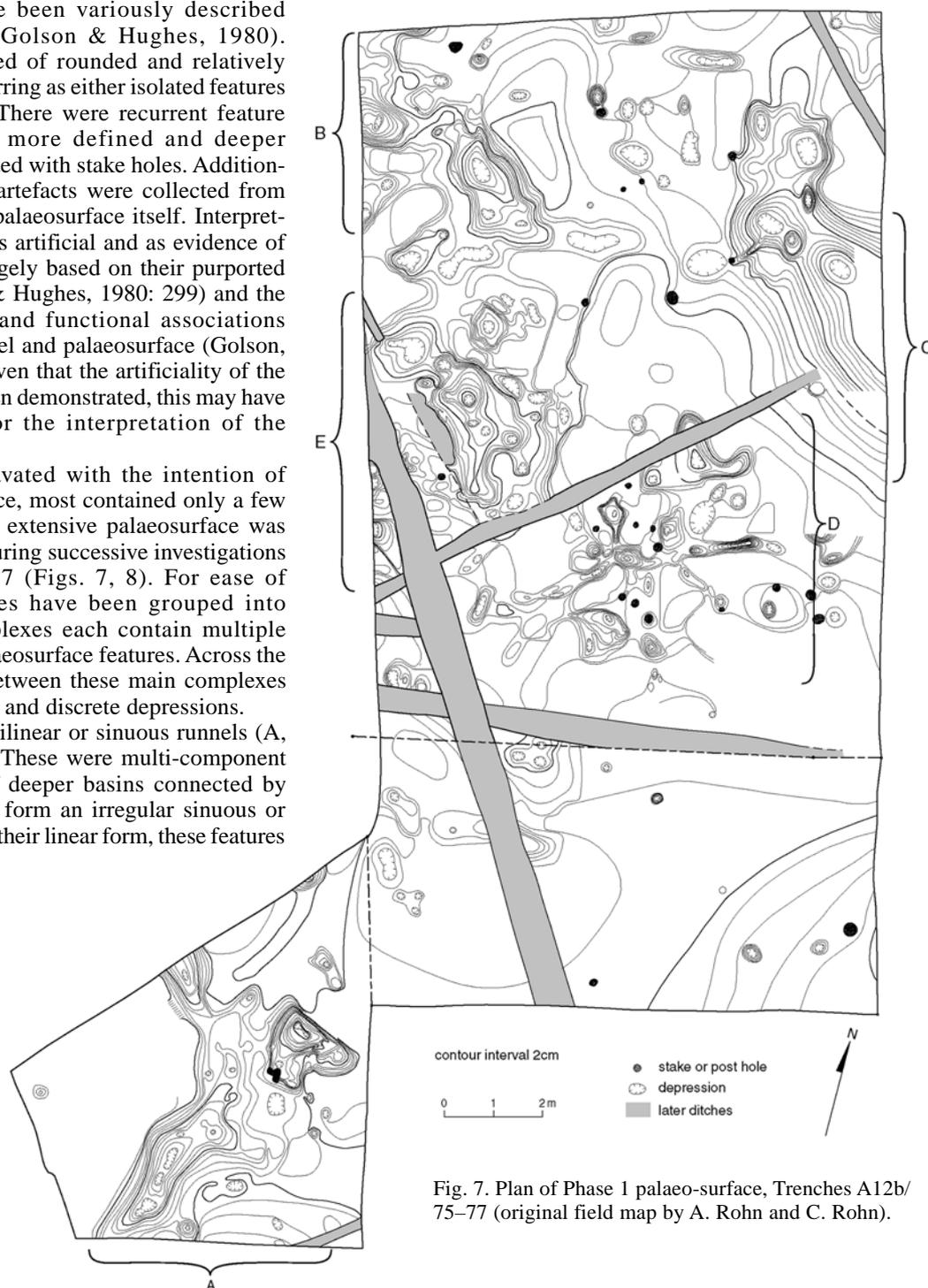


Fig. 7. Plan of Phase 1 palaeo-surface, Trenches A12b/75-77 (original field map by A. Rohn and C. Rohn).



Fig. 8. Photograph of Phase 1 palaeo-surface, Trenches A12b/75–77 (excluding 77–3) (taken by A. Rohn).

documented under grasslands in New Guinea (Bleeker, 1983: 248–258; Sullivan & Hughes, 1991). Even though the same processes may not apply at Kuk, it is plausible that some elements of the palaeosurface relief formed under grassland in wet conditions along a wetland margin. However, the stake holes and artefacts from palaeosurface contexts are definite evidence of a human presence at c. 9,000 B.P. The presence of *Musa* sp. phytoliths (of unknown section) from contemporaneous sediment samples may also represent human activity, although it is not at present known if the bananas were edible varieties or how they dispersed (Wilson, 1985). At present and on the existing evidence, it is not possible to differentiate the anthropogenic and non-anthropogenic components of the palaeosurface or to elicit the prehistoric practices of formation and use. Ongoing sedimentological and palaeo-ecological research by the author aims to enable more fine-grained reconstructions of the past environment and land use of this palaeosurface.

The original interpretation of the palaeosurface as agricultural was largely dependant on the artificiality of the palaeochannel. If the palaeochannel was artificial, then the most reasonable explanation would be for drainage of the wetland margin for the growing of crops. The palaeosurface provided the corroborating evidence for this interpretation, particularly given the analogies to the Phase 2 palaeosurface. However, the current evidence does not justify a claim of

artificiality for the palaeochannel, and the mode of formation of some palaeosurface elements is unknown. Thus, it has to be concluded that there is currently insufficient evidence to warrant a claim that the palaeosurface represents former agricultural activities.

Broadening the context

The review of the archaeological evidence for Phase 1 at Kuk has concluded that there is insufficient evidence to determine the artificiality of the palaeochannel and palaeosurface. Consequently, the claims for Phase 1 representing wetland agricultural activities at 9,000 B.P. are not justifiable. However, Golson has relied on multiple lines of evidence to establish a claim for agriculture at c. 9,000 B.P. What do these other lines of evidence suggest regarding the onset of agricultural-type activities in the highlands?

Two types of evidence present themselves: chronological and contemporary. Chronological evidence indicates change through time and includes archaeology, geomorphology and palaeo-ecology. Some forms of contemporary evidence can be used to infer past processes, e.g., contemporary distributions of people, plants and languages. Given limitations of space, it is possible to only draw out the main themes.

Chronological evidence: change through time

There is limited archaeological evidence from the highlands to indicate agriculture at around 9,000 B.P. No other wetland sites contain evidence of such antiquity and the lithic and faunal collections at rock shelters and caves have not provided any clear and well-dated diagnostics of a transition to agriculture (Aplin, 1981; Bulmer, 1966; Christensen, 1975; Mountain, 1991; White, 1972). Potentially, the most significant finds in the highlands have been uncovered at the open sites of NFX (Watson & Cole, 1977) and Wañelek (Bulmer, 1977, 1991), which date to c. 18,000 B.P. and c. 15,000 B.P. respectively. The presence of Late Pleistocene settlements in the highlands may be significant in terms of general assumptions about the association of sedentism and agriculture. However, even if these assumptions are tenable, it is not clear if the structures at these sites represent permanent as opposed to temporary habitation.

Table 2. Selected sites at which palaeo-environmental evidence of major anthropogenic disturbance in New Guinea has been identified. All ages given in uncalibrated radiocarbon years.

site	altitude (m)	commencement (age B.P.)	references
Kelela Swamp, Baliem Valley	1420	pre-7,000	Haberle <i>et al.</i> , 1991
Telefomin, Ifitaman Valley	1500	18,000–15,500	
		11,500–8,200	Hope, 1983
Kuk Swamp, Wahgi Valley	1580	pre-9,000	Powell, 1984; Haberle, pers. comm. research in progress
Lake Haeapugua, Tari Basin	1650	21,000	Haberle, 1998
Lake Wanum	35	8,500	Garrett-Jones, 1979
Lake Hordorli	780	11,000	Hope & Tulip, 1994
Kosipe Swamp	1960	c. 30,000	Hope & Golson, 1995
Lake Ijomba	3720	c. 11,000	Hope, 1996

The palaeo-ecological record, largely palynological, is more comprehensive. Several locations across New Guinea show periods of disturbance and firing in the Late Pleistocene and Early Holocene. Major clearance events have been documented for several large, inter-montane valleys along the highland spine of New Guinea, as well as for some higher and lower altitude sites (Table 2). The human origin of these disturbances can be inferred from the long-term decline in primary forest and concordant rises in secondary forest, grassland and charcoal frequencies (Haberle, 1994).

The most significant records are from Kuk. Powell's pollen diagram shows gradual increases in charcoal with minor disturbance of the primary forest from the Late Pleistocene until the beginning of the Holocene (Powell, 1980, 1984). Haberle's work on an early Holocene sediment sequence documents a change at c. 9,000 B.P. (Haberle, in progress). The change constitutes a decline in primary forest species and their replacement by a mosaic of secondary forest, swamp forest and open grassland. A peak in burning at this time suggests that the vegetation change was anthropogenic and driven by fire. At this time of increasing temperatures and wetter conditions, forests would be expected to be expanding at the expense of grasslands (Hope, 1989). These anthropogenic transformations are regional and can be traced in the pollen diagrams from Ambra Lake and Draepi, which register dramatic changes in the vegetation between the Late Pleistocene and mid-Holocene (Powell, 1970, 1981).

Palynological research provides corroborating evidence for previous interpretations that grey clay deposition represents sustained forest clearance for dryland agriculture at 9,000 B.P. (Golson, 1991; Golson & Hughes, 1980; Hughes, 1985). The deposition of grey clay marked a dramatic increase in erosion rates within the catchment (Hughes *et al.*, 1991). Taken together, the palynological and geomorphological records are clear evidence of major transformations of the dryland environment within the Kuk catchment from c. 9,000 B.P.

The presence of Late Pleistocene settlements and the widespread anthropogenic alteration of dryland environments in the highlands from this time suggest a major prehistoric trajectory in the interaction between people and their environment. Given the inference that people were oriented more towards plants than towards animals at this time (White, 1996), and possibly from initial settlement (Groube, 1989), these major environmental transformations were probably associated with crop production. With time and continued disturbance, people became more and more dependent on an anthropogenic landscape for their subsistence. Within this context, a scenario can be envisaged from which an "agricultural" relationship between people and their environment emerged.

Contemporary evidence: inferring the past from the present

Recent research in plant genetics has opened up new possibilities for the interpretation of plant, domesticate and agricultural origins in the Pacific. Approximately 25 years ago, at the time that the major archaeological and palaeo-ecological investigations were being undertaken in the Wahgi Valley, it was believed that many of the potential staples for prehistoric agriculture were imported domesticates from Southeast Asia (Yen, 1973). In the light of new biomolecular evidence, and occasional archaeological verification, a number of these crops are now interpreted as having been either first or independently domesticated in Melanesia (Haberle, 1995; Lebot *et al.*, 1994; Lebot, 1999; Matthews, 1991). Plants relevant to an understanding of agriculture at c. 1500 m altitude include taro (*Colocasia esculenta*), the greater yam (*Dioscorea alata*) and Eumusa bananas (*Musa* spp.). Although the timing of domestication is unknown, the potential availability of these major staples to food producers in New Guinea makes the possibility of highland agriculture more plausible.

The potential domestication of these crop plants in Melanesia makes Bellwood's edge-of-the-range hypothesis more applicable to the New Guinean context (e.g., Bellwood, 1996). Bellwood has proposed that agriculture may have developed in regions at the end of the last glacial cycle that were at or close to the ecological limits of utilizable plants. Given colder temperatures in the highlands at the end of the Pleistocene, a range of potential crops including taro, bananas and sugarcane (*Saccharum officinarum*) would have been at their altitudinal limits during this period (Haberle, 1993: 299–306; after Bourke, n.d.). The stresses upon these plants during any climatic fluctuations during this period necessitated increased human intervention to maintain yields. The increased levels of intervention potentially led to the development of agricultural practices. Such environmental forcing may well explain the documented, increased intensity of human disturbance within the Baliem and Wahgi valleys in the Early Holocene (Haberle, *et al.*, 1991; Haberle, pers. comm. and research in progress). Haberle's position, however, contrasts with Yen's conclusion that the majority of utilizable plants were originally found in the lowlands (Yen, 1995). According to Yen, crop plants adapted to higher altitudes as a result of agronomic selection. Irrespective of the ultimate location of domestication, either lowland or highland, the likely presence of these potential crops frees an indigenist perspective on agricultural development in New Guinea from a dependence on introduced Southeast Asian crops and techniques.

Drawing on the association between agriculture and large linguistic groupings, Pawley has proposed that the distribution of Trans New Guinea Phylum (TNG) languages, which cover most of New Guinea today and include the majority of its languages, was driven by agriculture (Pawley, 1998: 684). According to his speculative model, groups with agriculture were able to expand and displace or assimilate other non-agricultural language groups. With time this led to the demic diffusion of proto-TNG agriculturalists at the expense of non-pTNG and non-agricultural populations. These latter populations were marginalized into the least favourable, lowland locations. This model appears to fit

recent language maps for New Guinea, although there is insufficient published human biological evidence to corroborate the linguistic evidence. Although there may be many problems with the details of Pawley's general model, it is a plausible working hypothesis worthy of future investigation.

In summary, multiple lines of evidence seem to enable a proposition of independent agricultural origins in New Guinea. Geomorphological and palaeo-ecological evidence suggest that this may have occurred as early as the Late Pleistocene/Early Holocene. At present, however, there is no archaeological evidence for such an early presence of agriculture in the highlands or the lowlands.

Long-term agricultural trajectories: an open possibility

The archaeological evidence does not support claims of an agricultural origin for the palaeochannel and palaeosurface dating to c. 9,000 B.P. at Kuk. Rather than thereby dismiss such an antiquity for agriculture in New Guinea, it is proposed, following the line of argument of Golson and Hughes, that the palaeo-ecological and geomorphological changes witnessed at Kuk at this time mark the widespread clearance and utilization of the dryland landscape for productive purposes. Removing the ambiguous wetland archaeological evidence for Phase 1 at Kuk from the debate of agricultural origins in New Guinea shifts the focus of research to an explication of the productive practices occurring within the catchment and at the wetland margin during and after this period.

In recent years, the definition of agriculture has been decoupled from plant domestication (Harris, 1996; Hather, 1996; Ingold, 1996; Spriggs, 1996), and has been grounded according to scale, level of dependence or relative scope of human involvement. If such a decoupling is valid, then disturbance of inter-montane environments in New Guinea in the Late Pleistocene/Early Holocene, almost certainly to enhance food production from plants, is akin to "agriculture". At present the direct archaeological, sedimentological and archaeobotanical remains of these past practices and past crops have not been identified.

Over forty years after Bulmer excavated at Yuku and Kiowa rock shelters, the origins of agriculture in New Guinea remain elusive. This is not surprising, as the emergence of something "agricultural" from preceding crop production strategies, using Harris' (1996) terminology, may be difficult to trace in the New Guinean context. Certainly later agricultural practices do leave clearer traces in the wetlands, but those of earlier and emergent practices are not likely to be so definitive. The transformations of the inter-montane valleys in the Late Pleistocene and Early Holocene require explanation and are likely to signify the emergence of practices akin to agriculture, both in terms of their effects on the landscape and the dependence of people upon them for their subsistence.

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References

- Aplin, K., 1981. *Kamapuk Fauna: A Late Holocene Vertebrate Faunal Sequence from the Western Highlands District, Papua New Guinea with Implications for Palaeoecology and Archaeology*. Unpublished B.A. (Hons) Thesis, Australian National University, Canberra.
- Bayliss-Smith, T., 1996. People-plant interactions in the New Guinea highlands: agricultural heartland or horticultural backwater? In *The Origins and Spread of Agriculture and Pastoralism in Eurasia*, ed. D.R. Harris, pp. 499–453. London: UCL Press.
- Bellwood, P., 1996. The origins and spread of agriculture in the Indo-Pacific region: gradualism and diffusion or revolution and colonization? In *The Origins and Spread of Agriculture and Pastoralism in Eurasia*, ed. D.R. Harris, pp. 465–498. London: UCL Press.
- Bleeker, P., 1983. *Soils of Papua New Guinea*. Canberra: Commonwealth Scientific and Industrial Research Organisation in association with and Australian National University Press.
- Brown, A.G., 1997. *Alluvial Geoarchaeology: Floodplain Archaeology and Environmental Change*. Cambridge: Cambridge University Press.
- Bourke, M., n.d. *Altitudinal Limits of 220 Economic Crop Species in Papua New Guinea*. Unpublished manuscript held by author, Department of Human Geography, Research School of Pacific and Asian Studies, Australian National University, Canberra.
- Bulmer, S., 1964. Prehistoric stone implements from the New Guinea Highlands. *Oceania* 34(4): 246–268.
- Bulmer, S., 1966. *The Prehistory of the Australian New Guinea Highlands: A Discussion of Archaeological Field Survey and Excavations, 1959–1960*. Unpublished M.A. Thesis, University of Auckland.
- Bulmer, S., 1977. Between the mountain and the plain: prehistoric settlement and environment in the Kaironk Valley. In *The Melanesian Environment*, ed. J.H. Winslow, pp. 61–73. Canberra: Australian National University Press.
- Bulmer, S., 1991. Variation and change in stone tools in the Highlands of Papua New Guinea: the witness of Wañelek. In *Man and a Half: Essays in Pacific Anthropology and Ethnobiology in Honour of Ralph Bulmer*, ed. A. Pawley, pp. 470–478. Auckland: The Polynesian Society.
- Christensen, O.A., 1975. Hunters and horticulturalists: a preliminary report of the 1972–1974 excavations in the Manim Valley, Papua New Guinea. *Mankind* 10(1): 24–36.
- Garrett-Jones, S., 1979. *Evidence for Changes in Holocene Vegetation and Lake Sedimentation in the Markham Valley, Papua New Guinea*. Unpublished PhD thesis, Australian National University.
- Golson, J., 1977. No room at the top: agricultural intensification in the New Guinea Highlands. In *Sunda and Sahul: Prehistoric Studies in Southeast Asia, Melanesia and Australia*, ed. J. Allen, J. Golson and R. Jones, pp. 601–638. London: Academic Press.
- Golson, J., 1982. Kuk and the history of agriculture in the New Guinea Highlands. In *Melanesia: Beyond Diversity*, ed. R.J. May and H. Nelson, pp. 297–307, Canberra: Research School of Pacific and Asian Studies, Australian National University.

- Golson, J., 1989. The origins and development of New Guinea agriculture. In *Foraging and Farming: The Evolution of Plant Exploitation*, ed. D.R. Harris and G.C. Hillman, pp. 678–687. London: Unwin Hyman.
- Golson, J., 1991. Bulmer Phase II: early agriculture in the New Guinea Highlands. In *Man and a Half: Essays in Pacific Anthropology and Ethnobiology in Honour of Ralph Bulmer*, ed. A. Pawley, pp. 484–491. Auckland: The Polynesian Society.
- Golson, J., & P.J. Hughes, 1980. The appearance of plant and animal domestication in New Guinea. *Journal de la Société des Océanistes* 36: 294–303.
- Groube, L., 1989. The taming of the rain forests: a model for Late Pleistocene forest exploitation in New Guinea. In *Foraging and Farming: The Evolution of Plant Exploitation*, ed. D.R. Harris and G.C. Hillman, pp. 292–304. London: Unwin Hyman.
- Haberle, S.G., 1993. *Late Quaternary Environmental History of the Tari Basin, Papua New Guinea*. Unpublished PhD thesis, Australian National University.
- Haberle, S.G., 1994. Anthropogenic indicators in pollen diagrams: problems and prospects for late Quaternary palynology in New Guinea. In *Tropical Archaeobotany: Applications and New Developments*, ed. J.G. Hather, pp. 172–201. London: Routledge.
- Haberle, S.G., 1995. Identification of cultivated *Pandanus* and *Colocasia* in pollen records and the implications for the study of early agriculture in New Guinea. *Vegetation History and Archaeobotany* 4: 195–210.
- Haberle, S.G., 1998. Late Quaternary change in the Tari Basin, Papua New Guinea. *Palaeogeography, Palaeoclimatology, Palaeoecology* 137(1–2): 1–24.
- Haberle, S.G., G.S. Hope & Y. de Fretes, 1991. Environmental change in the Baliem Valley, Montane Irian Jaya, Republic of Indonesia. *Journal of Biogeography* 18(1): 25–40.
- Harris, D.R., 1996. Introduction: themes and concepts in the study of early agriculture. In *The Origins and Spread of Agriculture and Pastoralism in Eurasia*, ed. D.R. Harris, pp. 1–9, London: UCL Press.
- Hather, J.G., 1996. The origins of tropical vegetation: Zingiberaceae, Araceae and Dioscoreaceae in Southeast Asia. In *The Origins and Spread of Agriculture and Pastoralism in Eurasia*, ed. D.R. Harris, pp. 538–550. London: UCL Press.
- Hope, G.S., 1983. The vegetational changes of the last 20 000 years at Telefomin, Papua New Guinea. *Singapore Journal of Tropical Geography* 4(1): 25–33.
- Hope, G.S., 1989. Climatic implications of timberline changes in Australasia from 30000 YR B.P. to present. In *CLIMANZ 3. Proceedings of the Third Symposium of the Late Quaternary Climatic History of Australia*, ed. T.H. Donnelly and R.J. Wasson, pp. 91–99. Canberra: CSIRO, Institute of Natural Resources and Environment, Division of Water Resources.
- Hope, G.S., 1996. Quaternary change and historical biogeography of Pacific Islands. In *The Origin and Evolution of Pacific Island Biotas, New Guinea to Eastern Polynesia: Patterns and processes*, ed. A. Keast and S.E. Miller, pp. 165–190. Amsterdam: SPB Academic Publishing.
- Hope, G., & J. Golson, 1995. Late Quaternary change in the mountains of New Guinea. In *Transitions: Pleistocene to Holocene in Australia and Papua New Guinea*, ed. J. Allen and J.F. O'Connell. *Antiquity* 69, Special Number 265: 818–830.
- Hope, G., & J. Tulip, 1994. A long vegetation history from lowland Irian Jaya, Indonesia. *Palaeogeography, Palaeoclimatology, Palaeoecology* 109(2–4): 385–398.
- Hughes, P.J., 1985. Prehistoric man-induced soil erosion: examples from Melanesia. In *Prehistoric Intensive Agriculture in the Tropics*, part I, ed. I.S. Farrington, pp. 393–408. Oxford: British Archaeological Reports, International Series 232.
- Hughes, P.J., M.E. Sullivan & D. Yok, 1991. Human-induced erosion in a Highlands catchment in Papua New Guinea: the prehistoric and contemporary records. *Zeitschrift für Geomorphologie Suppl* 83: 227–239.
- Ingold, T., 1996. Growing plants and raising animals: an anthropological perspective on domestication. In *The Origins and Spread of Agriculture and Pastoralism in Eurasia*, ed. D.R. Harris, pp. 12–24. London: UCL Press.
- Lebot, V., 1999. Biomolecular evidence for plant domestication in Sahul. *Genetic Resources and Crop Evolution* 46: 619–628.
- Lebot, V., B.A. Meilleur & R.M. Manshardt, 1994. Genetic diversity in Eastern Polynesian Eumusa Bananas. *Pacific Science* 48: 16–31.
- Matthews, P., 1991. A possible wild type taro: *Colocasia esculenta* var. *Aquatalis*. In *Indo-Pacific Prehistory*, vol. 2, ed. P. Bellwood. *Bulletin of the Indo-Pacific Prehistory Association* 11: 69–81.
- Mountain, M.-J., 1991. *Highland New Guinea Hunter-Gatherers: The Evidence from Nombe Rockshelter, Simbu with Emphasis on the Pleistocene*. Unpublished Ph.D. thesis, Australian National University.
- Pawley, A., 1998. The Trans New Guinea Phylum Hypothesis: a reassessment. In *Perspectives on the Bird's Head of Irian Jaya, Indonesia*, ed. J. Miedema, C. Odé and R.A.C. Dam, pp. 665–690. Amsterdam and Atlanta: Editions Rodopi.
- Powell, J.M., 1970. *The Impact of Man on the Vegetation of the Mount Hagen Region, New Guinea*. Unpublished Ph.D. thesis, Australian National University.
- Powell, J.M., 1980. Studies of New Guinea vegetation history. *Proceedings of the IVth International Palynology Conference, Lucknow (1976–1977)* 3: 11–20.
- Powell, J.M., 1981. The origins of agriculture in New Guinea. *Proceedings of the IVth International Palynology Conference, Lucknow (1976–1977)* 3: 295–310.
- Powell, J.M., 1984. *Ecological and Palaeoecological Studies at Kuk I: Below the Grey Clay*. Unpublished manuscript held in Kuk Site Archive, Department of Archaeology and Natural History, Research School of Pacific and Asian Studies, Australian National University, Canberra.
- Smith, B., 1998. *The Emergence of Agriculture*. New York: Scientific American Library.
- Spriggs, M., 1996. Early agriculture and what went before in Island Melanesia: continuity or intrusion? In *The Origins and Spread of Agriculture and Pastoralism in Eurasia*, ed. D.R. Harris, pp. 524–537. London: UCL Press.
- Sullivan, M.E., & P.J. Hughes, 1991. Patterned micro-relief grasslands in cold upland valleys in Papua New Guinea. *Zeitschrift für Geomorphologie Suppl* 83: 8394.
- Watson, V.D., & J.D. Cole, 1977. *Prehistory of the Eastern Highlands of New Guinea*. Seattle: University of Washington Press.
- White, J.P., 1972. *OI Tumbuna: Archaeological Excavations in the Eastern Central Highlands, Papua New Guinea*. Terra Australis 2. Canberra: Department of Prehistory, Research School of Pacific Studies, Australian National University.
- White, J.P., 1996. Paleolithic colonisation in Sahul Land. In *Prehistoric Mongoloid Dispersals*, ed. T. Akazawa and E.J.E. Szathmary, pp. 303–308. Oxford: Oxford University Press.
- Wilson, S.M., 1985. Phytolith analysis at Kuk, an early agricultural site in Papua New Guinea. *Archaeology in Oceania* 20(3): 90–97.
- Yen, D., 1973. The origins of Oceanic agriculture. *Archaeology and Physical Anthropology in Oceania* 8(1): 68–85.
- Yen, D., 1995. The development of Sahul agriculture with Australia as bystander. In *Transitions: Pleistocene to Holocene in Australia and Papua New Guinea*, ed. J. Allen and J.F. O'Connell. *Antiquity* 69, Special Number 265: 831–847.

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<http://dx.doi.org/10.3853/j.0812-7387.29.2004.1413>

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<http://dx.doi.org/10.3853/j.0812-7387.29.2004.1414>